How to Use Tin Can Metal in Science Projects

Edward J. Skibness

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by EDWARD J. SKIBNESS

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WARNING

Remember that the materials and methods described here are from another era. Workers were less safety conscious then, and some methods may be downright dangerous. Be careful! Use good solid judgement in your work, and think ahead. Lindsay Publications Inc. has not tested these methods and materials and does not endorse them. Our job is merely to pass along to you information from another era. Safety is your responsibility.

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Preface

This book might have the sub-title: "How To Do Much Without Much." The three essentials in solving an experimental problem are materials, tools and "know how." The projects in this book are organized to help the young inventor or student to more easily solve his problems and to convert his ideas into realities.

Besides my personal experience with these projects in my general science classes, physics classes and science clubs, much encouragement has come from fellow science teachers, industrial arts teachers, scout leaders, parents and nurses in physical therapy. It has also been suggested that these projects can be of interest to one with hobbies, boys' clubs and to older retired persons with leisure time.

It is hoped that the projects described in this book will not only be of help to the experimenter but will give some satisfaction and pleasure in maintaining and exercising the relationship between mind and hand.

THE AUTHOR

Introduction

GENERAL DESCRIPTION:

Sheet metal offers an unlimited field for making educational toys and experimentation. In this age of canned foods the supply of sheet metal is abundant and the cost involved is only a few minutes of one's time to make articles as suggested in this book. The sheet metal from most tin cans is of sufficiently light weight so as to be worked easily with simple tools, and being tinned, it will take solder with no difficulty.

It is the purpose in the following pages to describe some of the most simple and useful processes and techniques that will help a young learner or experimenter how to convert tin metal from a tin can into most anything he may desire. As the experimenter progresses he will find new uses and applications of his own for these processes and techniques.

Making the projects described here requires no expensive tools, equipment or a special room. All the work can easily and safely be done on a kitchen table with ordinary simple hand tools. It is suggested, however, that a suitable box be obtained to contain the kit consisting of tools, jigs and materials.

In this series of projects in which tin metal is used as material, the processes involved are few and quite simple. Primarily they include first the marking and laying out of the material, then bending or folding the material, punching out holes, forming the material into tubes or cylinders and finally using an alcohol lamp for soldering the project.

MATERIALS:

The chief source of material for these projects is the common tin can. One need not avoid the tin cans that are coated on the inside or painted on the outside as such a coating

can readily be scraped away with a knife blade and leave a clean surface that will take solder easily.

The most desirable size of tin can to use is the No. 3 size. In this size the most metal for the least effort is obtained. Also this metal is light weight enough to be worked easily in doing most projects.

A lighter weight sheet metal, about .008 inch or less, can be obtained from a few tin cans such as soup cans and also from an old head gasket of an automobile engine. These lighter weight materials will be found most desirable for certain small parts.

Black stove pipe iron or any rusty or burned sheet metal will be found quite useful in making clamps and jigs to hold the parts in place while they are being soldered. Also a light-weight black iron stove pipe wire is used to hold parts in place while they are being soldered. Such clamps and wire bands are removed after the parts are soldered and have cooled.

The few items of material that one needs to purchase are a small can of soldering paste, some plain wire solder, some steel wool and a coil of black lightweight stove pipe wire.

TOOLS REQUIRED:

The tools required in making these projects are the ordinary hand tools found in a home. If one has available a hammer, a pair of pliers, an inexpensive tin snips, a hack saw blade, a three-cornered file and an alcohol lamp for soldering, he will have the tools most needed.

If the handle end of the three-cornered file is filed to a point, it will serve as a scratch awl, a center punch and as a reamer to make small holes larger. Other tools and jigs can be added to the tool kit as the need requires.

The jigs on which the tin can metal is formed consists mostly of cylinders such as common nails, dowels and empty

spools. An assortment of common nails should contain four or five of each kind of the sizes 4d, 5d, 6d, 8d, 10d, 16d, 20d, 30d, and 40d. These nails can be purchased as a one-pound assortment.

If nails are cut off square they will serve very well as punches for punching out holes in the tin can metal. Also, if the nails are filed and sharpened to a chisel point they will serve as a chisel when cutting out the larger holes in the tin can metal.

To complete the series of cylinders for jigs one should collect a variety of wooden cylinders from 3/8 inch to 1 1/4 inch in diameter. Besides empty thread spools, short lengths of dowel stock 3/8, 1/2, 5/8, and 3/4 inch should be added to complete the series of cylinders.

In addition to the above named tools and jigs an inexpensive carpenter's marking gauge and a nail set should be obtained. The marking gauge is especially useful when several metal strips of the same size are needed. Because the nail set has a tapered end it is useful to enlarge small holes and expand tubes that are slightly too small.

PROCESSES AND TECHNIQUES

LAYING OUT MATERIALS:

Fig. 1

One of the most important processes is to properly mark and lay out the materials to be worked. To help in laying out the materials, as well as providing a place on which to work them, the work board shown in FIG. 1 is suggested. For this board the end piece of a wooden orange crate or apple box will serve the purpose very well. For an added convenience fasten along one edge of the board an inexpensive ruler as shown in figure 1. A thin narrow wooden strip, ⅛″ x 1″ x 12″, will serve just as well except for the measurements. The ruler or wooden strip can be fastened to the board with small wire nails. You will find the ruler or strip especially useful when using triangles for marking square and other given angles.

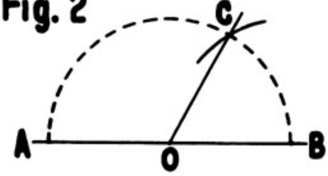
Angles of any definite size can be formed by first laying out the angle on a sheet of paper. The metal angle can then be bent or cut until it coincides with the angle on the paper.

HOW TO LAY OUT ANGLES:

A method for laying out some of the more common angles is shown in FIGS. 2, 3, and 4. In FIG. 2, first draw the line AB. Then at a point O on this line as a center use any distance from O as a radius to draw a semi-circle as shown by the dotted line. Then from the point where the semi-circle cuts the line AB use the same radius to locate

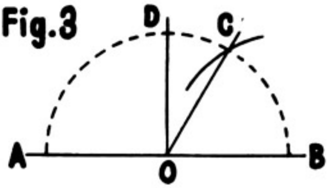
the point C on the semicircle. Through this point draw the line OC. The angle formed by line OC and the line OB will be 60 degrees, and the angle formed by line OC and OA will be 120 degrees.

Fig. 2



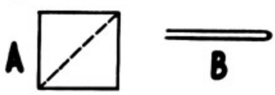
If the line OD is drawn perpendicular to line AB at point O, as shown in Fig. 3, the angle formed by lines OC and OD will be 30 degrees and the angle formed by lines OD and OA will be 90 degrees.

Fig. 3



A 45-degree angle can best be made by first drawing a square as shown in Fig. 4A. Then draw the diagonal as shown by the dotted line. The two triangles formed are both 45-degree triangles. A 180-degree angle is made by simply folding a line over onto itself as shown in Fig. 4B.

Fig. 4



HOW TO GET THE METAL FROM A TIN CAN:

Obtaining the metal from a tin can is not a big problem. Primarily it involves getting rid of the rim at the ends of the can. If one has the use of a can opener mounted on the wall the problem is quite simple. This type of can opener can be operated so as to leave the rim attached to the end piece, or to the can portion as desired. If, however, only the unmounted can opener is available, then either of the following methods will do the job.

The simplest method is to first cut out the remaining end piece. Then with the tin snips cut along both sides of the side

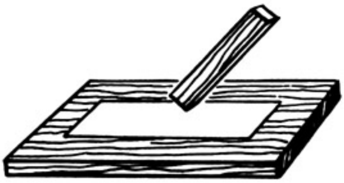


Fig. 5

seam. Next open and flatten out the tin metal as far as possible and with the tin snip cut away the rim on each edge. The sheet of metal obtained is next placed on a piece of board and with the end of a stick as shown in FIG. 5, or using the head of your hammer, smooth or iron out any wrinkles or unevenness along the edges of the tin metal sheet. Do not hammer or pound the metal.

A second method for obtaining the sheet metal from a tin can involves the removing of the rim or the end piece of the tin can with an old jackknife. To remove the end piece of the tin can begin cutting at the seam on the side of the can as shown in FIG. 6, and continue cutting close to the rim on around back to the seam. By bending the end piece away from the can a few times, the seam will break off.

Fig. 6

Fig. 7

To cut away the rim at the open end of the tin can, hold the can firmly against a piece of board as shown in FIG. 7. Again with a jackknife begin cutting at the seam and continue on around as before by cutting close to the rim. Then bend the rim away from the can to break the seam. Next you cut on each side of the seam on the side of the can, to open the can. Then flatten and make smooth the metal sheet as described above. This method can also be used to cut a can to any desired height.

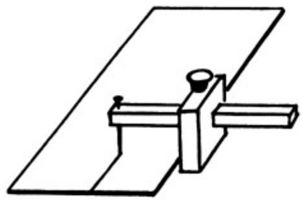


Fig. 8

HOW TO MARK TIN METAL FOR STRIPS:

The most common method used to mark for strips is to use a carpenter's marking gauge as shown in FIG 8. If a carpenter's marking gauge is not available, then a simple marking jig, shown in FIG. 9C, can easily and quickly be made. Such a jig is made from a piece of tin metal ⅝ inch wide and long enough to contain the width or gauge of two strip sizes.

To make such a jig for marking strips ⅜ and ½ inch wide first cut from tin can metal a piece ⅝″ x 1¼″. Then through the middle of the piece the long way, draw a line as shown by the dotted line in FIG. 9A. On this line mark three points with short cross lines. The first point is 3/16 inch in from one end; the second point is ⅜ inch in from the first point and the third point is ½ inch from the second point.

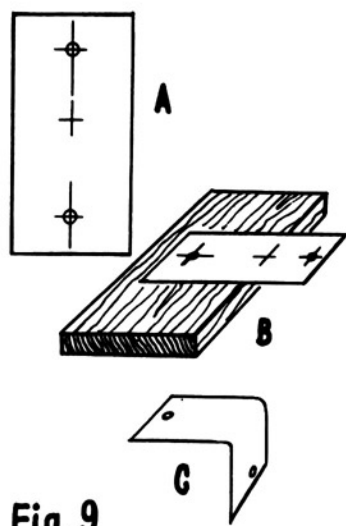


Fig. 9

The next step is to use a 4d nail to punch small holes through the piece of metal at the first and third short cross lines as shown in FIG. 9A. Then use a file to remove some of the burr around the holes raised by the nail. Make the holes just large enough for the point of a large safety pin or a sharp pencil point. Then place the piece of metal on a piece of board so that its second short cross line will be over a straight sharp edge of the wood as shown in FIG. 9B.

Now bend the outer end of the metal piece down against the board to form a sharp right angle as shown in FIG. 9C.

Fig. 10

FIG. 10 shows how to use the jig for marking strips. First check the sheet of metal to see that its edges are straight. Then place the sheet of metal on a board so that an edge of the metal overhangs slightly an edge of the board. The jig is then placed over the edge of the metal at one end and with a pencil point or a safety pin point in the top hole of the jig it is pulled or pushed along the edge of the metal to mark the strip.

An assortment of such marking jigs for different size strips could be stored in a penny match box in one's tool kit for future use.

TO MAKE A SIMPLE BEND:

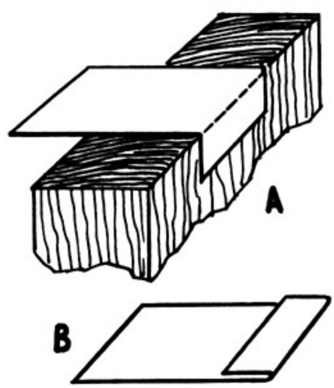


Fig. 11

A simple, easy way to bend a piece of sheet metal so that it will form a straight and smooth edge is to first mark a line on the metal to show where the bend is to be. Then place the marked line over a straight, sharp corner on a block of wood and, holding the metal firmly against the block, bend down the extended portion to a right angle as shown in FIG. 11A. Then if the right angle formed is bent over onto the strip, it will make a fold as shown in FIG. 11B.

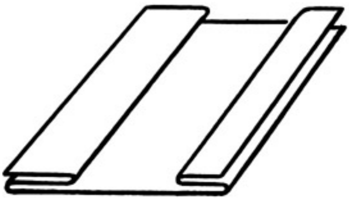


Fig. 12

USING A BENDING JIG:

A simple and convenient jig for bending and folding sheet metal is shown in FIG. 12. If one has two such jigs he can form most of the common bends such as 3/16, ¼, ⅜, and ½ inch. One great advantage of a jig is that many equal bends can be repeated without having to measure or mark for them.

PUNCHING OUT HOLES:

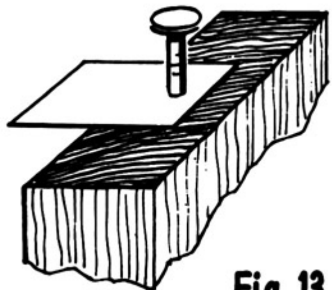


Fig. 13

To punch out holes in sheet metal with a nail cut off square you first place the metal on the end grain of a block of wood as shown in FIG. 13. Be sure the block is held firmly in a vise or on a solid foundation. Then hold the punch firmly against the marked hole on the metal and with a hammer strike the first blow to the punch gently so you can check to see if the hole is started in the right place. Make the second blow hard enough to drive the punch through the metal. Next you turn the metal over on the block and hammer back the raised edge or burr around the hole.

It sometimes helps to paste a piece of paper to the metal with the hole marked on the paper. The punch then is less apt to move or slip on the paper. The punch selected should be slightly larger than the hole desired.

The smaller holes are punched with the sharpened handle end of a file or a nail and the raised burr is filed away. Using the same tapered handle-end of a file the hole can be reamed out and enlarged to the desired size.

HOW TO FORM TUBES AND CYLINDERS:

The simplest method for forming from tin can metal a tube or cylinder as shown in FIG. 14A is to form a tin metal strip one or more turns around a nail or other cylinder. The all important step is that the beginning end of the strip is made to conform to the curvature of the nail or cylinder as shown in FIG. 14B.

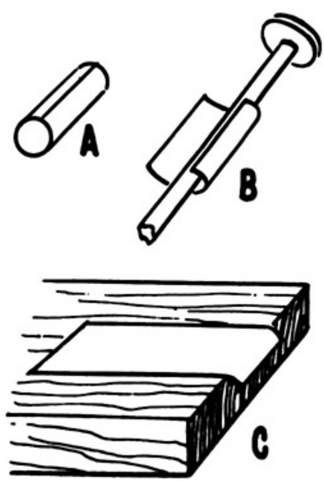


Fig. 14

This can be done either with your pliers or by first using a hammer for rounding the end of the metal strip over the end of a piece of wood as shown in FIG. 14C. Also by using a smaller nail or cylinder for the first turn will help to make a more perfect tube or cylinder. The surplus strip is cut away after having added the desired number of turns. If the formed portion is only one turn it should be far enough around the cylinder to overlap for soldering.

To make a formed tube or cylinder more round, solid and near perfect, it should be placed on a flat board with its forming cylinder inside and then with pressure on a narrow piece of board over it, rolled a few times in one direction only as shown in FIG. 15A.

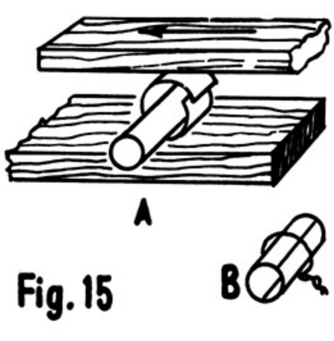


Fig. 15

After the tube or cylinder has been rolled, one or more black iron wire bands are placed around it as shown in

FIG. 15B. The bands will hold the tube or cylinder solid while being soldered. You next apply soldering paste to the tube or cylinder and then solder it either by immersing in melted solder or by applying wire solder to it in an alcohol flame.

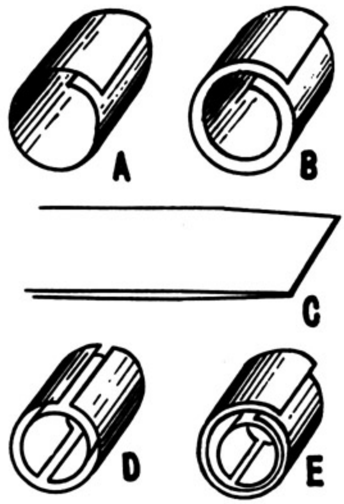


Fig. 16

SPECIAL TYPES OF TUBES:

Tubes or cylinders that need to be smooth and true on the inside are made as shown in FIG 16. Such tubes or cylinders would be used as bearings or as cylinders with a moving piston inside.

In making cylinder 16A or 16B the first step is to lay the tin metal strip on a flat piece of wood and then from about ½ inch in from the end of the metal strip file the end to a sharp edge as shown in FIG. 16C. Next form and roll the sharpened end of the strip on a nail or cylinder as described in FIG. 15. FIG. 16A is a cylinder with only a little more than one turn and FIG. 18B has two or more turns.

The cylinder shown in FIG. 16D is made by telescoping two sleeves of the same size so that the inner sleeve forms a butt joint. To make the two sleeves first determine the exact circumference of the inner sleeve. Then cut from tin can metal two pieces of the same size. The circumference being the length of the pieces and the length of the cylinder being the width of the pieces.

You first form and roll the pieces of metal on a cylinder a little smaller in diameter than the cylinder is to be. Then place one of the sleeves formed over a cylinder about the

same diameter as the finished metal cylinder. With a hammer tap the sleeve gently all the way around until the ends of the metal piece begin to open. You next do the same with the other rolled sleeve and then place one sleeve inside the other as shown in FIG. 16D.

The final step is to place one or more iron wire bands around the metal cylinder and tighten the bands until the butt joint in the inner sleeve is closed. Then apply soldering paste to the inner closed joint and to the outer open joint. The metal cylinder can then be soldered either by immersing it in melted solder or by applying wire solder to it in an alcohol flame.

FIG. 16E is a single sleeve with a butt joint placed inside a tin metal cylinder with two or more layers or turns that will give it added strength. This metal cylinder is made and processed the same as all those described before.

SUGGESTIONS FOR FINISHING PROJECTS:

The finished appearance a project presents always adds to the pride and satisfaction it gives the owner. Here are a few suggestions that will help to give the project a finished appearance.

Sheet metal parts with exposed sharp corners should have these sharp corners slightly snipped off or filed slightly round as shown in FIG. 17. Such sharp corners are not only unattractive but quite apt to cut and injure your hands.

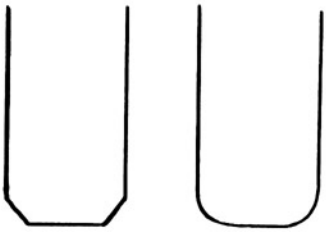


Fig. 17

Excess solder should be shaken off while the part is still hot. Sometimes, while the part is still hot, the excess solder can be wiped off with a piece of cloth, a brush or a splinter

of wood. After the part has cooled the excess solder can best be scraped off and removed with a jackknife blade.

If the project has a wooden base, the base should be planed and the upper edges slightly rounded. After the base has been sanded it should be painted or shellaced. Shellac mixed with lampblack makes a very attractive black finish and one that dries quite quickly. Aluminum paint also makes an attractive finish.

How to Make Useful Equipment

HOW TO MAKE AN ALCOHOL LAMP:

In the process of making projects from tin can metal the alcohol lamp shown in FIG. 1 is most helpful. By it the tin metal pieces can be soldered and joined together to make up the parts desired.

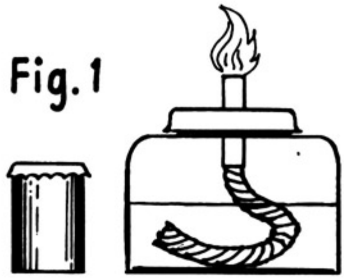


Fig. 1

The materials needed to make an alcohol lamp are an ink bottle or a similar small bottle with a metal screw top, a piece of tin metal 1¼ inch square and a 4-inch length of cotton clothes line for a wick.

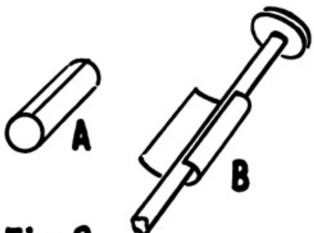


Fig. 2

The first step is to form a 1¼″ x 1¼″ piece of tin metal into a tube. This is done by first using your pliers to form the piece of metal around a 40d nail as shown in FIG. 2. Be sure the inner edge of the piece of metal conforms to the curvature of the 40d nail.

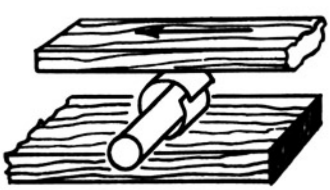
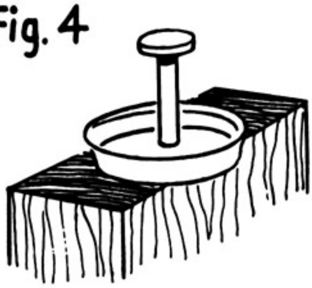


Fig. 3

The next step is to place the tube formed, with the 40d nail inside, on a flat board or surface and with another narrow board roll the tube in one direction only as shown in FIG. 3. It is the rolling that makes the tube round, true and the proper size.

The second step is to punch out a hole at the center of the metal screw bottle top as shown in FIG. 4. First place the metal screw top upside down on the end grain of a block of wood that is held firmly in a vise or placed on a solid foundation. Then place a 40d nail cut off square at the center of the metal screw top and with a hammer drive the 40d nail through the metal to punch out the hole. You next scrape and clean the metal around the hole on the inside of the screw top so that the metal will take solder.

Fig. 4



If the tube you made is too large to fit into the hole in the screw top, then ream out the hole by turning a three-cornered file in it until the tube will fit into the hole snugly. You now adjust the tube so that the outer end extends out about ½ inch.

The next step is to apply a small amount of soldering paste to the screw top and the tube where the two join. If a wire band is placed around the screw top as shown in FIG. 5, the twisted ends will serve as a handle by which you can hold the top with your pliers while doing the soldering. Hold the screw top inverted and place a piece of solder the size of a BB shot against the tube so that when it is melted it will flow around and fasten the tube to the screw top. The flame from two matches held under the screw top is sufficient to melt the solder.

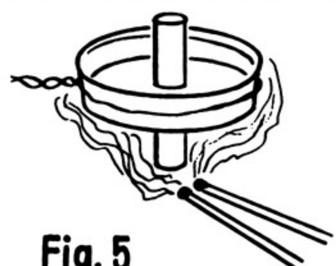


Fig. 5

You next insert a 4-inch length of cotton clothesline through the tube so it extends a half inch above the tube.

Then fill the bottle half full of denatured alcohol and the lamp is ready to use. Do not use any other fuel as it may be dangerous in addition to burning with a dirty smoke.

A douser for putting out the flame is shown beside the lamp in FIG. 1. It can be made from a piece of tin metal 1″ x 3½″ and an ordinary bottle cap. First form the tin metal strip around a ¾-inch cylinder (empty spool) and then roll it on the cylinder as shown in FIG. 3. You next place the metal cylinder formed into a bottle cap and hold it in place with a piece of iron wire as shown in FIG. 6. With your pliers kink the wire band on the two sides to bring the cap and metal cylinder into closer contact. Also place a black iron clamp over the lap at the outer end of the cylinder. Then apply soldering paste to the cap and cylinder, and to the lap on the side, where the parts are to be fastened together. You next drop into the open end of the assembly a piece of solder the size of a pea. Then with your pliers hold the assembly inverted in an alcohol flame and rock and rotate the assembly so that the solder will flow around the edge and along the lap on the side.

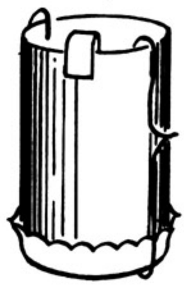


Fig. 6

The first step in any form of soldering is to be sure the metal is scraped clean and is of the kind that will solder. Soldering paste or some other type of soldering salt is always applied to the metal where it is to be soldered. This is to help clean the metal and to make the solder flow more easily. Only enough paste to cover the area to be soldered should be used.

There are three ways in which an alcohol lamp can be used for soldering. One method is to first fasten the parts into place with non-soldering metal clamps or with black iron wire bands. Then apply the soldering paste and with

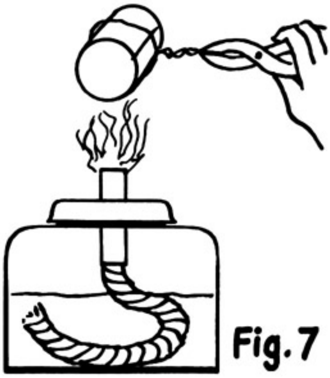


Fig. 7

your pliers hold the assembly in the alcohol flame as shown in FIG. 7. When the soldering paste is well melted and the tin metal begins to appear wet you apply wire solder to the joints. If too much heat is applied the tin metal will burn or oxidize and refuse to solder. This is one way of making a non-soldering tin metal clamp.

While the metal parts are still hot the excess solder should be shaken off into a tray as the one shown in FIG. 8. This solder in the form of small pellets is convenient to pick up with a soldering iron when soldering that way. The tray can be made from scrap lumber ⅜ to ¾ inch thickness and a 4 x 5 inch area. The rim is a ⅛″ x ½″ strip (peach box cover) fastened to the base with small brads. This tray is also convenient when re-tinning a soldering iron and using sal ammoniac powder.

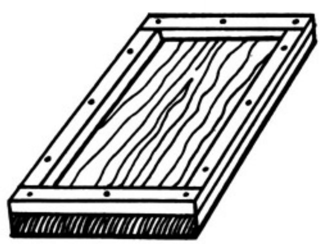


Fig. 8

A second method for soldering with an alcohol lamp is to use the flame to melt solder in a small ladle and then dip or immerse the prepared parts in the melted solder. This requires some form of support to hold the ladle over the flame. A very simple such support is shown in FIG. 9A. It is a modified No. 2½ tin can turned upside down over the alcohol lamp to form a small stove.

To modify the tin can first cut out a 1½-inch hole at the center of the closed end of the can. This can be done by first marking the hole on the can and then placing the can invert-

ed over a 2″ x 2″ block of wood. Next use a 10d nail filed or sharpened to a chisel point and a hammer to cut the metal on the marked line.

To allow free circulation of air inside of the can it is necessary to punch a row of holes ¾ inch apart all around the can near the rim at the closed end of the can. These holes are punched with a pointed 10d nail and a hammer.

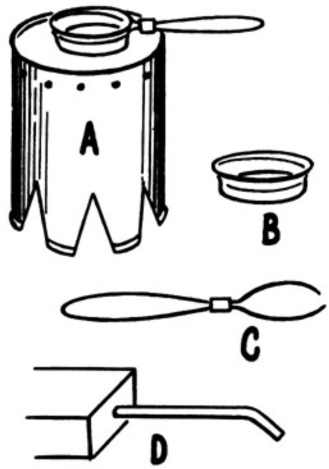


Fig. 9

The final step is to provide the alcohol lamp inside of the can with sufficient fresh air. To do this it is best to make about 6 or 8 deep V cuts with your tin snips into the open end of the can.

The small ladle in which the solder is melted is shown in Fig. 9B. It is a 1½ inch, or larger, screw bottle cap. The handle for the small ladle is shown in Fig. 9C. It is a 10-inch length of coat hanger wire that is first bent 180 degrees at its middle. Then around the two legs of the bent wire, 2 inches from the open end, is placed or wound 1½ turns of a ½-inch tin metal strip to serve as a band to hold the legs together. The two outer ends of the legs are then bent outward to right angles. With your pliers then form the two ends back inward to make two semicircles as shown in Fig. 9C. The ladle is now placed into the formed open circle and so that it is held firmly.

If one needs ladles that are larger in diameter the same procedure can be followed. A convenient ladle for extra long parts can be made from sardine cans or kippered herring cans.

FIG. 9D shows a small makeshift soldering iron for doing fine delicate soldering. It is a 10d nail driven into the end of a stick. At ½ inch in from the outer end the nail is bent to almost a right angle to make it better to use. This outer end is filed and cleaned so that it will take and hold solder. To use this small soldering iron, dip the outer end into melted solder and hold it there until it is hot. Then transfer it to the small job it is to do and where it will leave a small bit of solder.

To solder with an ordinary soldering iron the metal is prepared in the same manner as described before. The only difference is the method of supplying the heat and solder. The most important point to keep in mind when using a soldering iron is that the iron be well tinned and that it is hot enough to melt solder. To tin the soldering iron first file the iron clean. Then heat the iron in a smokeless flame such as an alcohol lamp or a blow torch. Next apply a little soldering paste to the end of a piece of wire solder and touch it to the cleaned hot iron. If the iron does not take the solder, then the iron must be filed and cleaned some more until it will take the solder applied along with soldering paste.

Another method for tinning the soldering iron is to place on the tray shown in FIG. 8 about a teaspoonful of sal ammoniac powder. Then rub the hot iron in the sal ammoniac while at the same time apply solder to the iron. Having the sal ammoniac on the tray makes it possible to re-tin the iron continuously while soldering. One must always avoid heating the iron too hot as this will oxidize (burn up) the tinning and even the iron itself. To do satisfactory soldering with a soldering iron requires much patience and practice. Most difficulty is due to using a soldering iron that is too small for the job or the metal is not clean. The beginner should avoid metals that do not solder or clean easily.

How to Make A Bending Jig

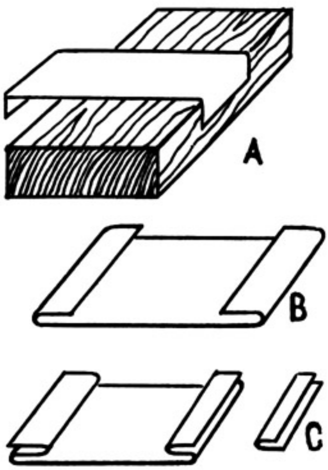


Fig. 1

The forming, bending or folding of sheet metal can be simplified a great deal by using a bending jig. Usually a bending jig makes it unnecessary to measure or to mark for a bend or fold. The bending jig described here is quite worth the time it takes to make it or what it might cost to have it made at a tin shop. A good bending jig should be made from No. 28 gauge or heavier sheet iron. However, if used carefully, one made from tin can metal will serve very well.

To make a 3/16 and ¼-inch bending jig first cut from tin can metal a piece 2″ x 2½″. Place this piece of tin metal on a piece of board so that one end extends 3/16 inch out over a straight, sharp edge of the board. Then hold the piece of metal firmly against the board and with your thumb push the extended part down against the board to form a right angle as shown in Fig. 1A. Now do the same at the other end of the piece of tin metal except that the bend is ¼ inch in from the end. Then with your thumb push the two bends inward to form the two folds as shown in Fig. 1B. Now place a double thickness of tin can metal in one of the folds and with your pliers pinch the fold completely shut. Before removing the double strip of metal in the fold, use your pliers to bend the fold evenly downward and inward to form a

second fold. This second fold should be slightly less deep than the first fold. With the pliers pinch the second fold completely shut. Now transfer the double tin metal strip to the fold at the other end of the piece of metal and then make this fold the same as the other fold. The finished jig is shown in Fig. 1C.

To make the bending jig more rigid, an added fold shown in Fig. 1D is made and slipped over each of the first two folds in the jig. By following the above same procedure another jig for ⅜ and ½-inch bends and folds can be made. These two bending jigs should solve nearly all possible needs in bending light weight metal.

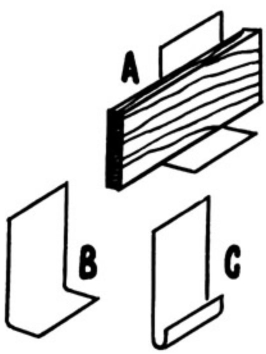


Fig. 2

Should one desire to make a bend or fold less than 3/16 inch it can be done in the following manner. First make a right angle bend of any size. Then as shown in Fig. 2A, place in the right angle a thin piece of board or cardboard the same thickness as the width of the bend or fold desired. With the tin snips then cut away that portion of the bend extending out from the board or cardboard to make the shorter bend shown in Fig. 2B. The short bend is then bent inward to form the short fold shown in Fig. 2C.

How to Make Triangles for Marking

Quite often one finds it necessary to lay out lines that are at some fixed angle such as 90, 45, 30 and 60 degrees. All these angles can be included in a set of two triangles. However, two such sets will be made.

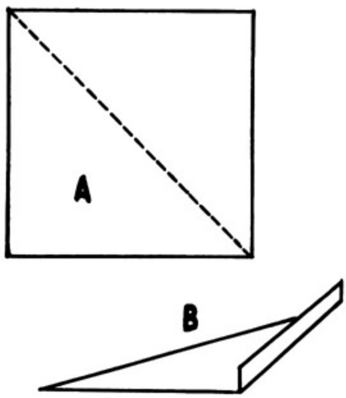


Fig. 1

The first triangles to lay out and make is for the 90 and 45 degree angles. This involves first the cutting from a piece of tin can metal a 4 or 5-inch square. A piece is square if the diagonals (distance between opposite corners) are equal. On the square draw one diagonal as shown by the dotted line in Fig. 1A.

By cutting the square on the dotted diagonal line you obtain the two desired 90 and 45 degree triangles. Then use a bending jig to bend one of the two equal sides of one of the triangles upward to a right angle as shown in Fig. 1B. If the corresponding side of the second triangle is bent downward to a right angle your triangles can be used to mark both right and left angles.

The triangles for the 30 and 60-degree angles involve first the cutting out from a piece of tin can metal a rectangle that is twice as long as wide, such as one 3″ x 6″. Then lay out this rectangle as shown in Fig. 2A.

In a 30 and 60-degree triangle the long side is twice the length of the short side. Therefore, you will use the long

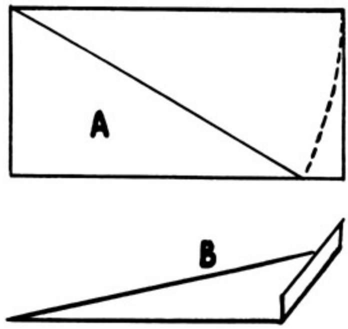


Fig. 2

side of the rectangle as a radius and with a compass draw from a short side corner an arc to the opposite long side and as shown in FIG. 2A. From the point where the arc meets the opposite long side draw an angular line to the opposite corner as shown by the dotted line in FIG. 2A. You next cut on the dotted line to divide the rectangle into two 30 and 60-degree triangles. Then use the bending jig to bend the short side of one triangle upward to a right angle as shown in FIG. 2B. Next bend the short side of the other triangle downward to a right angle. You will now have triangles for marking both right and left angles.

How to Make A Mandrel

Fig. 1

The mandrel shown in Fig. 1 is really a tube which has been so modified as to give it a taper. It is quite useful when making certain projects. Perhaps its most important use is to round out or enlarge holes that have been either punched or cut out in sheet metal. It is also useful in forming collars and bushings. One should make up a set of at least two sizes so as to have a range in taper from ¼ to 1¼ inch.

To make the first and smaller mandrel cut first a rectangle 3″ x 6″ from tin can metal. Then at one end of this rectangle make a mark ¾ inch in from the corner on the short side. Next at the opposite corner on the short side make a mark ⅞ inch in from the corner. Between the two marks made draw a line as shown by the dotted line in Fig. 2. Then on this line cut the rectangle to make two tapered pieces.

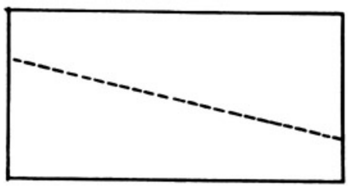


Fig. 2

The simplest method to curve and form the metal pieces is to lay them over the end grain of a ¼-inch board which has been fastened in a vise or nailed to a block of wood. Let a long edge of the metal piece extend over the edge of the board not more than ¼ inch. Then with a hammer or a wooden stick tap the edge of the metal gently so as to give the edge a gradual curve as shown in Fig. 3. Give this treat-

ment to the whole length of this edge and repeat the treatment in the same manner to the other long edge.

Next with the palm of your hand bend, curve or sort of mold the metal over the end of the ¼-inch board to make the metal piece as near round as possible. You then proceed to give the same treatment to the second piece of tapered metal.

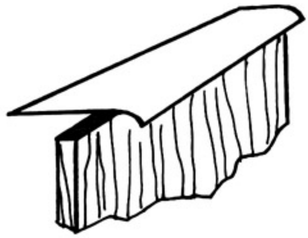


Fig. 3

The next step is to join the two tapered pieces by slipping one inside of the other. Since the small end of one piece is less than that of the other it is the piece to go inside. The open space in the inner piece should be opposite the open space in the outer piece as shown in Fig. 4.

Fig. 4

You next place iron wire around the mandrel at about one inch apart. Then tighten the bands until the outer open space is about 1/16 inch wide. Then apply soldering paste to the inner open space as well as the outer open space. Hold the assembly in an alcohol flame and apply wire solder to the outer open space and then to the inner open space.

When the iron wire bands are removed the outer open space should be gone over with a file to remove any excess roughness. If necessary the outer open space can best be filled with a soldering iron. Also the surplus metal at the larger end should be snipped away.

The second mandrel in size is made by first cutting from tin can metal a rectangle 5½″ x 6″. At 2 inches in from a corner on a short side of the rectangle make a mark. Then at 2⅛ inches in from the opposite corner on the shorter side

make another mark. Between these two marks draw a line and proceed from there as you did before for the smaller mandrel.

Even though your mandrels may seem rough, uneven and untrue they will still do quite well the things you expect them to do.

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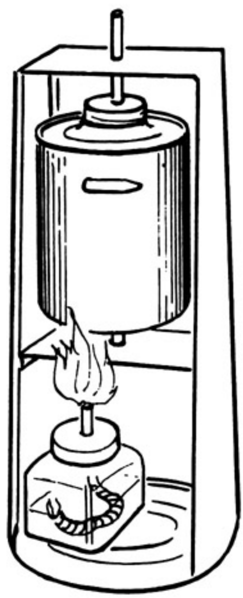
HERO'S JET ENGINE



This steam engine is a 100 years B.C. model. The following directions will tell you how to build a Hero jet propelled steam engine.

Hero's steam engine dates back to 100 years B.C. and is really a jet propulsion engine. It is the most simple as well as the most inefficient of all the steam engines. If the bearings are not almost frictionless the engine may not operate.

The following directions for building a Hero engine are adapted to the skills of an inexperienced amateur, using only such tools and materials that are easily available.

The materials needed for building this engine are a clean half pint tin can for a boiler, the metal from a No. 3 clean uncoated tin can for the other parts and some light weight sheet copper for the jets. The sheet copper can be obtained from an old head gasket of an automobile engine. Other materials needed are a few shingle nails, some black stove pipe wire, a piece of coat hanger wire, soldering paste and some plain wire solder.

The few simple tools needed are a tin snip, a pair of pliers, a hammer, a hack saw blade, a 6-inch three-cornered file and

an alcohol lamp for soldering. If a piece of cloth or friction tape is wrapped around one end of the hack saw blade, it will need no other frame or handle.

The greatest difficulty in building this Hero engine may be to find a suitable tin can to use for a boiler. If possible one should find a ½-pint can with a screw cap or friction cap in the center of its top. This screw cap makes it simple to put in or take out the water. The second choice is a ½-pint paint or putty can with a friction cover. If such a can is used it should be made as clean as possible on the inside. In any case the height of the can should not exceed 2½ inches.

A third possibility is to use two ordinary tin cans of the same size; one for the boiler portion and a short section of the other to be telescoped into the first as its top or cover.

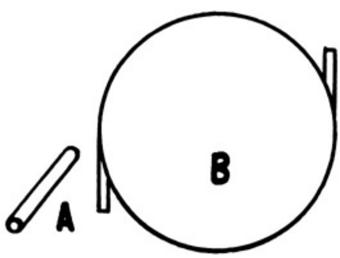


Fig. 1

The first part of the boiler to make are the two jets from which the steam escapes to make the engine operate. The two jets are tubes made from clean pieces of light weight sheet copper such as may be obtained from an automobile head gasket. Cut two copper pieces ½" x ¾" and form and roll the copper pieces the long way on a shingle nail to make the tubes as the one shown in FIG. 1A. These tubes can also be made from light weight tin metal such as from a soup can, in which case the tube should have only a turn and a half of metal.

The next step is to locate on the boiler the two holes for the two jets. These two holes are on the exact opposite sides of the boiler ½ inch down from the top rim. Punch these holes first with a shingle nail and then ream them out with the handle end of a three-cornered file until the tubes fit the

holes snugly. Then with a shingle nail inside each tube in each hole force the tubes to the right as far as they can go. This will place the tubes parallel to the circumference and against the boiler as shown in FIG. 1B.

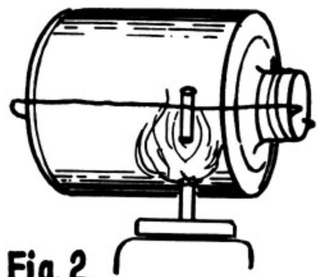


Fig. 2

The tubes are next soldered to the boiler as shown in FIG. 2. First scrape and clean the metal around the holes so that the metal will take solder. Then apply soldering paste to the tubes and boiler where they are to join. Next hook a piece of black iron wire into the open end and then around the bottom of the boiler in such a manner that it will hold the tubes in place against the boiler while being soldered. A short piece of black wire should also be inserted into the tubes to prevent them from being filled with solder.

In doing the soldering first place a piece of solder the size of a BB shot between the tube and boiler. Then hold the boiler in an alcohol flame as shown in FIG. 2 and heat until the solder flows freely. Then hold the boiler out of the flame to let the solder set. A wet cloth applied to the boiler will cool it quite rapidly so that the same process can be repeated with the other tube.

It is necessary to close up the tubes slightly so that the boiler can build up pressure. To do so first place inside the tube a tapered tin metal strip. This strip is about 2 inches long, ⅛ inch wide at one end and pointed at the other end. Insert the pointed end of the strip into the tube as far as it will go. Then with the pliers pinch the tube shut and withdraw the strip.

The next part of the boiler to add is the shaft. It is made from a wire coat hanger and consists of three parts as shown

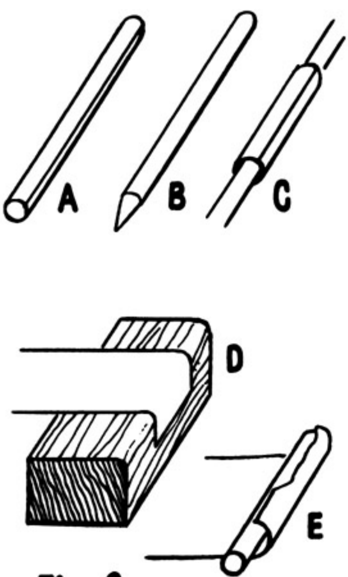


Fig. 3

in FIG. 3. In the figure, A is the top section, B is the pointed lower section, and C shows the tube or sleeve that connects the two sections. All three parts are each 2½ inches long.

The tube or sleeve is best made from a strip of lightweight tin metal 2½ inches wide. First place the end of the tin metal strip over a slightly rounded corner of a block of wood and so that it extends out a scant 3/16 inch. Then bend the end down to a right angle as shown in FIG. 3D.

You next place a wire section of the shaft against the right angle bend and with a hammer or some other object fold the end of the tin metal strip inward over the shaft as shown in FIG. 3E. Then with the pliers hold the shaft and folded strip while you add another half turn of the strip. Next cut away the surplus strip and with the pliers make the tube or sleeve as round as possible.

The next step is to file and clean about one inch of the upper shaft section at one end so it will take solder. Then file and clean about one inch at one end of the lower shaft section. Also at this end file the end to a sharp conical point which is to rest in the lower cone bearing.

To most easily and accurately locate the holes in the boiler that are to receive the shaft, first draw circles on a piece of cardboard the exact size of the bottom of the boiler and the inner area of the cap or cover.

You next cut out the round cardboard disk for the cover and fit it to the inside of the cover. Then with a 6d nail make a dent in the cover at the center of the cardboard disk. Next remove the cardboard disk and scrape the metal clean around the dent on the inside of the cover so that the metal will take solder.

Then place the 6d nail in the dent and with a hammer drive the nail through the cover to make the hole for the shaft. Now place the upper end of the upper shaft section in the hole and drive it through the hole to ¾ inch from the inside end. Next apply soldering paste around the hole and shaft and then lay a small piece of solder against the shaft. Then hold the assembly in an alcohol flame as shown in FIG. 4 and heat until the solder flows around the shaft.

Fig. 4

The lower shaft section at the bottom of the boiler is added in much the same way as described for the cover. First cut out the cardboard disk for the bottom and fit it to the inside of the rim on the bottom. Then with a hammer and a 6d nail dent the boiler at the center of the cardboard disk. Then remove the cardboard disk and scrape the metal clean around the dent so that the metal will take solder.

You next place the 6d nail in the dent and with a hammer drive the nail through the bottom of the boiler to make the hole for the shaft. Now place the pointed end of the lower shaft section in the hole and drive the shaft through the hole to make it the right size. Then pull the shaft section out and prepare it for the assembly.

To prepare the shaft or assembly you first apply soldering paste to the pointed end to about ¾ inch in. Then hold the pointed end in an alcohol flame and apply solder to the

shaft so as to tin the end of it inward about ¾ inch. Apply enough solder so you get a gob of it adhering to the shaft.

When the lower shaft section has cooled the blunt end of it is inserted into the hole in the boiler so far that the pointed end extends out about ¾ inch. The sleeve or tube (3C) is then slipped over the shaft inside the boiler and the lower end of the upper shaft section is also inserted into the sleeve. When the cap or cover is screwed onto the boiler it will hold the lower shaft section in place while being soldered as shown in FIG. 5. When the solder on the shaft begins to melt tilt the boiler so as to make the solder flow down to the boiler and around the shaft.

Fig. 5

If the can selected for the boiler is a paint can with a friction cover the same steps and directions will apply. It may be well, however, to have in the cover a hole with a cork or stopper as shown in FIG. 6. To make this hole, set the cover on the end grain of a wooden block and with a 40d nail cut off square and a hammer punch out the hole. With a mandrel or other tapered object ream and enlarge the hole to about ⅜ inch. Use a small cork or wooden plug in the hole while the engine is operating.

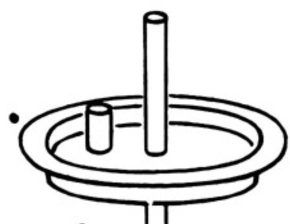


Fig. 6

If a suitable can for a boiler is not readily at hand a boiler as shown in FIG. 7 can quickly and easily be made by using the closed end portion of two ordinary No. 2 or No. 2½ tin cans. For this the coated cans are satisfactory and are less apt to rust out.

By using the second method shown in "How to get the metal from a tin can," cut one can to a 2½-inch length for the boiler proper and the other ¼ inch high for the cover. A simple method for marking the length of the part wanted is to cut a strip of paper as wide as the part is to be high and long enough to go around the can. Place the strip around the outside of the can and with a pencil mark the can along the edge of the strip.

Fig. 7

Before starting to cut the can with your jackknife, punch a hole with a 6d nail about ¼ inch out from the marked line and near the seam of the can. The hole will give you a safe place to start the point of the knife blade. Cut the can about ¼ inch out from the marked line all the way around and back to the seam. Then bend the seam back and forth until it breaks off. Use your pliers to straighten the wrinkled edge of the can. Now place the paper strip you used for marking the outside into the inside of the can and with your snips trim the can to the edge of the paper strip.

The cover is obtained in the same manner as the boiler portion. Its height, however, is only ¼ inch. In order to slip the cover inside the boiler part the edge of its skirt must be crimped slightly about every ½ inch. This can be done with the pliers. Work the cover skirt into the boiler part with the point of a knife blade. This process tends to stretch the boiler portion so that soon the cover will slip in. After the cover has been in place once it can be taken out and replaced again quite easily.

The directions for making and adding the jets, shaft and hole for water intake for this boiler are the same as was described before. When the jets, shaft and the hole for the water intake have been added to the boiler the cover is

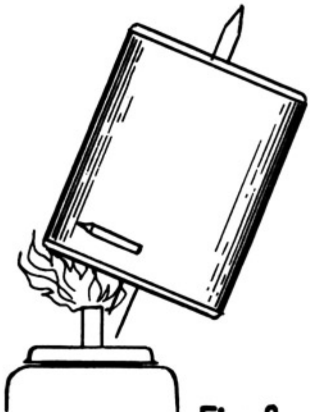


Fig. 8

forced into the boiler as far as it can go.

Next apply soldering paste along the edge between the boiler and the cover and then hold the boiler in the alcohol flame as shown in Fig. 8. When the metal seems hot enough touch wire solder to the boiler edge and cover and let the melted solder flow down along the edges and on around as you turn the boiler.

The supporting frame consists of two tapering uprights and two cross pieces. To make the supporting frame you first cut from a tin metal sheet from a clean uncoated No. 3 can a piece of tin metal 4″ x 7″. On this piece lay out the tapering strips as shown in Fig. 9. First on the short side at one end of the piece make a mark 1½ inches in from the corner. Then from the opposite corner also on the short side of the sheet make a mark 1½ inches in from the corner. Next draw a solid line between the two marks as shown in Fig. 9. This line will divide the metal piece into two tapered strips that are 7 inches long, 1½ inches wide at one end and 2½ inches wide at the other end. Through the middle lengthwise of each tapered strip

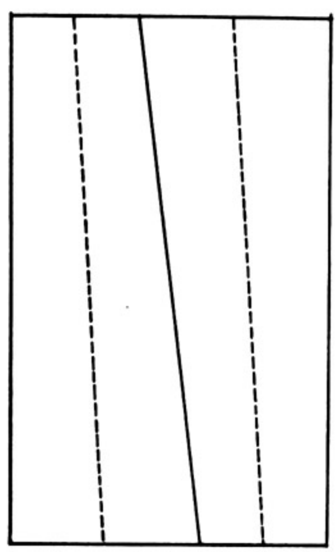


Fig. 9

draw a dotted center line as shown by the dotted lines in FIG. 9. You next cut the metal piece on the solid line.

Since the ends of the tapered strips are not square with the center lines it is important that they be trimmed to be square. The simplest way to mark the ends square with the center line is shown in FIG. 10. The squaring jig is a square piece of drawing paper about 3″ x 3″ folded at its middle and so that one straight edge overlaps itself evenly. Squeeze the fold so it will show a line. When the paper jig is opened the fold line will be square with the straight edge.

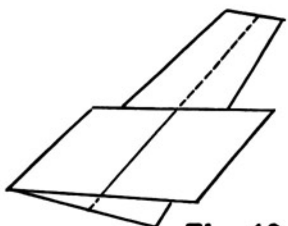


Fig. 10

To use the jig you place it over the tapered metal strip so that the fold line is directly over the dotted center line. Then mark the metal strip along the straight edge as shown in FIG. 10. The metal outside the marked line is then cut away.

The next step is to cut from the same piece of metal stock (No. 3 tin can) the two cross pieces 1½″ x 4″. Also cut four pieces 1″ x 1″ for the corner angle pieces and two ½″ x 1½″ for the middle pieces. Before forming the cross pieces draw on each the diagonals as shown in FIG. 11. This will locate the centers where bearings for the shaft will be. In the lower cross piece at the center make a light dent with a 6d nail and at the center of the upper piece drive the 6d nail through the metal. Then ream and enlarge the hole so the shaft will fit it easily.

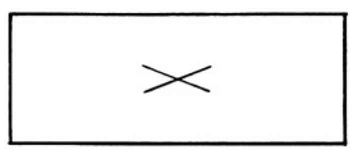


Fig. 11

The next step is to fold the long edges of the tapered upright strips and the two cross pieces. The folds are all ¼

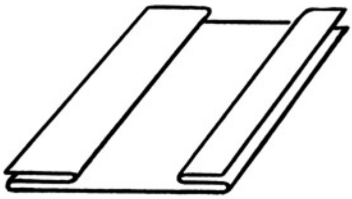


Fig. 12

inch and can best be made with a folding jig such as the one shown in FIG. 12. This jig was made to make 3/16 and ¼-inch folds. In using this short jig bend the edge only a little each time as you move the jig back and forth along the edge until the fold is made as shown in FIG. 13A.

You next lay the folded pieces on a flat surface and so that the folds are up. Then with a piece of wood stroke the folds hard enough to close them as shown in FIG. 13B.

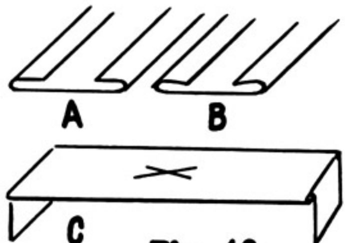


Fig. 13

When the folds are all made the next step is to bend sharply all the 1″ x 1″ at their middle to a right angle. Then add this angle piece to each end of the two cross pieces as shown in FIG. 13C. If necessary, pinch the fold to make the angle piece stay in place.

In assembling the frame the first step is to insert the projecting angle ends of the top cross piece (the one with the hole in it) into the small ends of the tapering uprights. The cross piece at the middle of the frame is held in place by first slipping under the two folds of each upright a ½″ x 1½″ tin metal strip. The lower edge of these cross strips should be placed at 3 inches from the wide lower ends of the uprights. The projecting angle ends of the middle cross piece are then slipped under the short cross strips in the uprights.

When all the members of the frame are in their proper place the joints of the assembly are soldered in an alcohol

flame as shown in FIG. 14. Before soldering, the frame should be checked to see that it stands upright firmly and squarely on a flat surface without rocking.

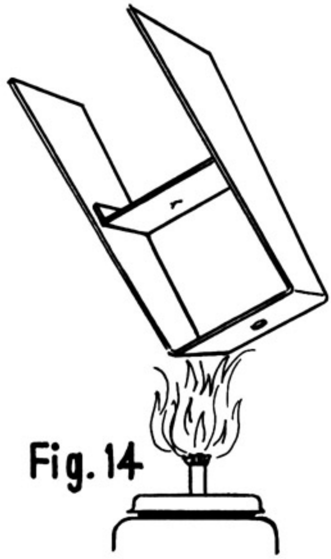


Fig. 14

The closed bottom or end piece of a No. 3 tin can is just right for the base of the engine. To fit the frame to the engine base first curve slightly the wide lower ends of the uprights so they will fit around the bottom piece firmly. Then place the base with the rim downward on a flat surface and straddle the frame over it. The frame should grip the base tightly enough to hold it in place while being soldered in an alcohol flame.

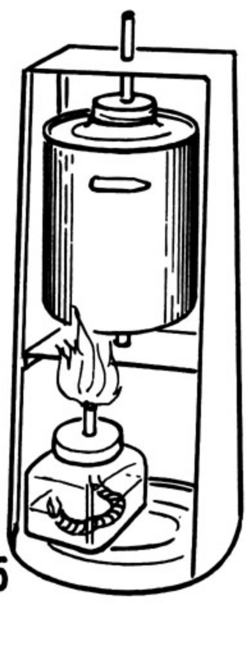


Fig. 15

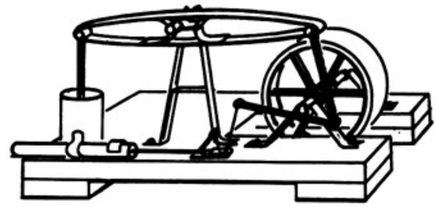
The finished engine with the boiler and alcohol lamp in proper position is shown in FIG. 15. To operate the engine place water in the boiler to a depth of about ¾ inch. It will take from 5 to 10 minutes to generate steam and pressure enough to turn the boiler. If the engine fails to operate one should check to see that the bottom shaft is filed to a point. Also it may be necessary to pinch or close the jets slightly to get more pressure.

The appearance of the engine can be made more attractive by applying a coat of paint to it. Any paint will be satisfactory for the frame but aluminum paint is better for the boiler as this paint is less affected by heat.

Section III

THE WALKING BEAM ENGINE

1760 MODEL



HOW TO BUILD A WALKING BEAM ENGINE

The walking beam steam engine is essentially the steam engine that James Watt designed in 1760 when he made over or redesigned a Newcomen atmospheric engine that was built in 1705.

The following directions for building a walking beam engine requires no skill and needs only a few simple tools such as an inexpensive tin snip, a pair of pliers, a 6-inch three-cornered file, a hack saw blade and an alcohol lamp for soldering.

Since this walking beam engine is made up of several unit parts, it will lend itself nicely to be used as a class or group project to illustrate our modern scheme in industrial production. Each member of the class or group will be assigned to make a unit part which will be combined with the unit parts made by the other group members to make one single engine.

The metal parts are made from ordinary tin can material. In general the smaller cans, such as soup cans, have lighter weight material and therefore can be more easily formed for the smaller parts. For the larger metal parts the material from any clean, bright and uncoated tin can can be used. Coated tin cans can also be used if the metal is scraped and cleaned so that the parts or pieces formed will take solder.

Other needed materials are: an assortment of four or five of each kind of common nails from 4d to 40d on which to form parts, a ¼-inch (hole size) plated cut washer for the piston, a ¾-inch cylinder (thread spool) on which to form the engine cylinder, some ¼-inch crate wood for the base and nine ¼-inch round headed screws for fastening

the parts to the engine base. You will also need some wire solder and paste for soldering the parts and some lightweight black stove pipe wire for holding the parts in place while being soldered.

Fig. 1

The base for the walking beam engine is shown in FIG. 1. It is made by first cutting from ¼-inch crate wood two pieces 1½″ x 5″ and one piece 1″ x 5″.

To help saw the pieces for the base more accurately, use a bench hook or a jig as shown in FIG. 2. A hack saw blade with tape or cloth wrapped around one end for a handle makes a handy, inexpensive saw for either wood or metal. With this saw the best results are obtained if the cutting is done while pulling the saw blade towards you.

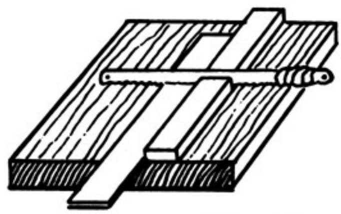


Fig. 2

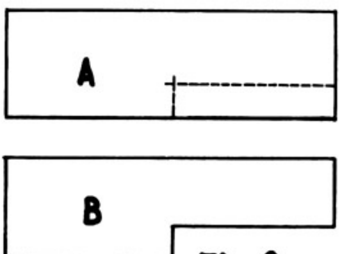


Fig. 3

Having cut the three pieces of wood, the next step is to draw a light line across the middle of the two 1½-inch pieces. Then from this line on each piece, ½ inch in from the edge, draw a line to one end as shown in FIG. 3A. With your hack saw blade now cut in on the short middle lines as far as the ½-inch lines. Then with a jackknife cut away the wood in small amounts at one end of each piece as far in as the ½-inch line to make the two pieces appear as shown in FIG. 3B.

If the wood has not been planed the three pieces should now be made smooth. First, with No. 2 sandpaper and then

with No. 1 sandpaper. Lay the sandpaper on the bench hook or a flat surface and rub the wood against the sandpaper as shown in Fig. 4.

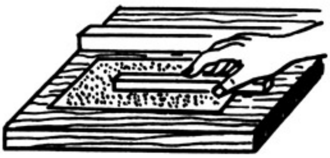


Fig. 4

The next step is to assemble the base as shown in Fig. 1. First place the 1″ x 5″ piece underneath the wide ends of the two 1½-inch pieces and so that one end of it is even with one side, and its side is even with the ends of the wide pieces. Then with ½-inch wire nails fasten the three pieces together. With your hack saw blade cut away the extended portion of the 1-inch piece even with the side of the base. The 1″ x 2″ piece obtained is then cut at its middle to make the two feet for the open end of the base. Again use ½-inch wire nails to fasten the feet to the base. If the nails extend through the base and feet they should be bent over and clinched. The base should now be sandpapered and painted with black shellac or any ordinary paint.

The simplest way to locate on the base the spots where the screws for holding the several engine parts will be, is to make a templet as shown in Fig. 5. The templet is a piece of paper that is cut and marked to show the details and size of the base.

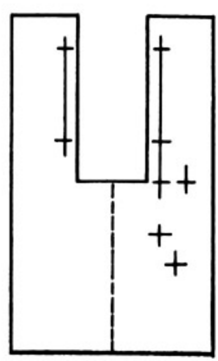


Fig. 5

On this templet at the open end of the base, on each side of the opening, draw lines 3/16 inch in from the two edges. On these lines, ½ inch in from the open end of the base, draw short cross lines. Then 1¼ inches farther in on the same lines draw another pair of short cross lines.

On the line to the right of the opening 1½ inches from the second short cross line or screw spot draw a short cross

line. Then to the right of this screw line at the middle of the base draw a short middle line. On this middle line 5/16 inch in from the right edge of the base draw a short cross line.

At ½ inch in from the right long edge of the base, and 1¼ inches in from the closed end of the base, draw a pair of short cross lines. At 5/16 inch in from the closed end of the base, and 1¼ inches in from the right long edge of the base, draw the final pair of short cross lines.

To use the templet lay it properly over the base and with a sharp pointed object punch through the paper templet into the base at all the short cross lines to locate the screw spots on the engine base.

Into each screw spot on the engine base, screw in almost all the way a ¼-inch No. 2 or No. 3 round headed screw. This will complete the base and make it ready to receive the several engine parts as they are completed.

The two bearings and their supports are the first of the engine parts to be made. They are the simple type made by forming two ¼″ x 3″ tin metal strips as shown in Fig. 6. This bearing and support has the advantage that it is easily adjustable.

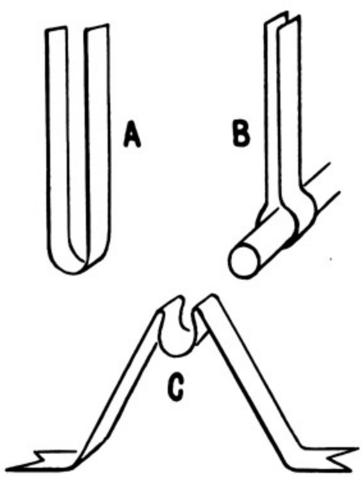


Fig. 6

First fold the ¼″ x 3″ tin metal strips at their middle over an 8d nail to form a U as shown in Fig. 6A. Then with your pliers pinch the legs of the U together close to the nail as shown in Fig. 6B. Now place two or more

turns of string around the two legs close to the nail and then bend the two legs outward and around so that they will point in the opposite direction.

You next remove the string and form the feet by bending the outer ends of the support legs outward from ¼ inch in on the legs. To receive the screws that hold the support to the base you either cut V slots in the feet with your tin snip or place the feet on the end grain of a piece of wood and punch holes with an 8d nail cut off square. The finished bearing and support is shown in FIG. 6C. Next fasten the two bearings and supports to the engine base.

The second part of the engine to make is the crank and crankshaft shown in FIG. 7A. The shaft is an 8d nail with its head cut away and the crank arm and pin are made from tin can metal.

First cut from lightweight tin metal (soup can) a strip 1/16″ x 4″. Form this metal strip around a jig made by rounding the corners of a piece of wood ⅛″ x ½″ as shown in FIG. 7B. The formed metal strip will be a link as shown in FIG. 7C.

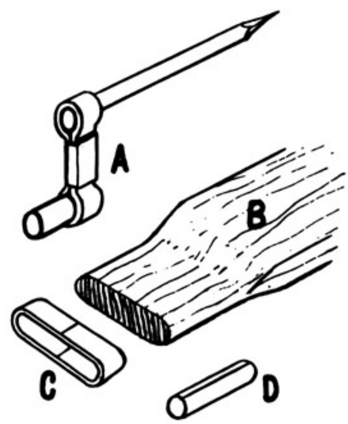


Fig.7

To make the crank pin you cut a ¼-inch strip of lightweight tin metal and form one end of it a scant two turns around a 5d nail to make a tube as shown in FIG. 7D. Then cut away the surplus strip and with your pliers make the small tube as round as possible on the nail.

To assemble the crankshaft, first place the shaft, 8d nail, at one end of the link and the crank pin at the other end. Then with a narrow pair of pliers pinch the sides of the link

together. This can also be done by placing a narrow piece of wood above and below the link and with a hammer strike the top piece of wood.

To better hold the shaft and pin in place while being soldered, and also to strengthen the crank arm, form a sleeve of a turn and a half of a 3/16-inch tin metal strip around the link between the shaft and the crank pin. After cutting away the surplus strip tighten the sleeve around the arm with your pliers.

The next step is to solder the crankshaft assembly. This can be done either by immersing it in melted solder or by holding it in an alcohol flame while applying the wire solder. First check to see that the end of the shaft and the end of the pin are even with their edge of the link. Then apply the soldering paste and proceed to solder.

While the assembly is still hot give it a few quick shakes to remove the excess solder and especially that which is inside the pin. After cleaning the crankshaft it is placed in its bearings on the engine base. If the crank arm strikes the bearing support the crank arm should be bent outward slightly and its pin realigned.

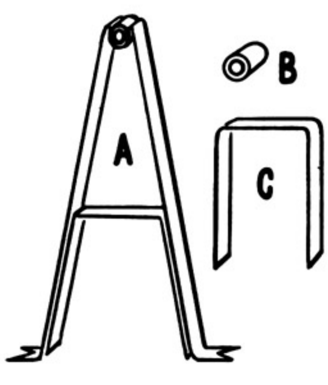


Fig. 8

The walking beam bearing and its support shown in FIG. 8A is made exactly the same as the crankshaft bearings and supports except for adding to it an inner brace and an inner bearing.

The tin metal strip for the beam bearing and support is ¼″ x 6″. It is formed on an 8d nail in the same manner as the bearings and supports described and shown in FIG. 6.

The inner bearing, 8B, is a

¼″ x 1″ tin metal strip first formed around an 8d nail and then rolled in one direction only on a flat surface as shown in Fig. 9. Rolling the bearing on the nail makes it not only more round and solid but gives it the proper size.

The inner brace of the support, Fig. 8C, is a tin metal strip ¼″ x 3″ formed by bending both ends in the same direction to a right angle 1⅛ inches in from the ends. The brace is placed inside the support legs so that the two ends of the legs will be even with the feet of the support.

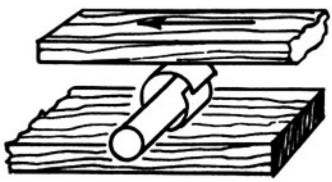


Fig. 9

While the brace is being soldered it is held in place with four small clamps. The clamps are made by winding a ⅛-inch non-soldering metal strip once and a half around the support and brace and then cutting away the surplus strip. The assembly then can be soldered either by immersing it in melted solder or by applying the wire solder in an alcohol flame. Next you add the beam support to its proper place on the engine base.

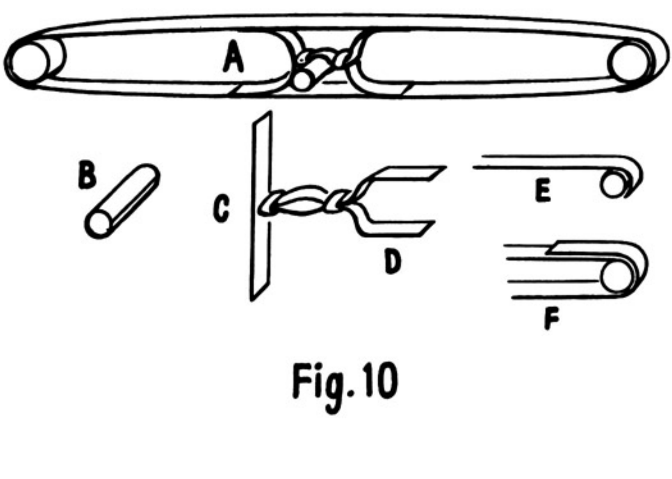


Fig. 10

To make the walking beam for the engine, as shown in FIG. 10A, you first make the small hollow shaft shown in FIG. 10B. This shaft is made by first forming a scant two turns of a ½-inch lightweight tin metal (soup can) strip around a 5d nail. Then cut away the surplus strip and with your pliers make the tube (shaft) as round as possible on the nail.

The second part of the beam to make is that inner part at the middle that holds the shaft and is shown in FIG. 10C and 10D. This part is made up of two pieces of tin metal 3/16" x 2". First hold the two metal strips together with their ends even. Then at ¾ inch in from each end place around the two strips a band or clamp. These bands are a turn and a half from a tin metal strip 1/16 inch wide.

The next step is to first bend the ends of the two metal strips outward from each other to a right angle as shown in the figure at 10C. Then bend the ends back and form them over a ⅜-inch cylinder so they will be shaped as shown in the figure at 10D.

At the middle of the inner assembly between the clamps use a very sharp point to separate the strips so that the handle end of a small file can be inserted to enlarge the opening just enough to receive the hollow shaft (10B) snugly.

The outer portion of the beam is made from two 3/16" x 5" tin metal strips. First form both ends of one strip once and a half around an 8d nail as shown in FIG. 10E. Then lay the second strip alongside the first strip so that the outer ends are of equal length. Then bend both extended ends down around the formed ends of the first strip. Now slip out the first strip and turn it over and slip it back inside the second strip as shown in FIG. 10F. At the ends where the strips overlap place a small band or clamp of a non-soldering metal strip 1/16 inch wide.

Since the two shafts that operate in the bearings at the ends of the beam are the same as the pivot shaft, the pivot shaft can be used to check the beam bearings for size. If necessary, enlarge the bearings with the handle end of a file. The bearings should fit the pivot shaft quite freely. Also be sure the distance between the centers of the bearings is 3½ inches.

The next step is to place the formed inner part between the two outer strips at their middle and so that the distances between the center of the pivot shaft and the centers of the outer bearings is 1¾ inches.

To hold the inner part in place while you solder the assembly, place bands from a 1/16-inch non-soldering metal strip around the inner and outer beam strips where they contact. If one of these bands is made long enough (1½ inches) its ends can be twisted together to provide a projection by which the assembly can be held with a pair of pliers while being soldered. The assembly can be soldered either by immersing it in melted solder or by applying the wire solder in an alcohol flame.

The final step is to insert the small hollow shaft at the middle of the walking beam into the bearing of the beam support. If the shaft does not fit the bearing loosely the bearing can be reamed and enlarged slightly with the tapered handle end of a small file.

To hold the shaft in place in the beam bearing make a small key as shown in Fig. 10H. This key is made by first forming a 1/16″ x 1″ tin metal strip at its middle over an 8d nail. Then with your pliers pinch the legs of the strip together close to the nail to form an eye as shown in Fig. 10G. Next remove the nail and while holding the formed strip with your pliers close to the eye, flatten the eye against the pliers with a hammer. After the key is inserted through

the hollow shaft the two legs of the key are spread to right angles.

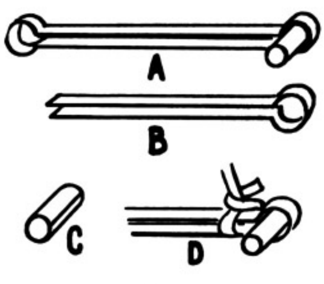


Fig. 11

The connecting rod that connects the crank to the walking beam is shown in FIG. 11A. It has a bearing at one end and a short shaft or pin at the other end. To make the rod, first cut two 1/16″ x 3″ tin metal strips. Then fold the two strips at their middle over an 8d nail and with your pliers pinch the two legs of the strips together close to the nail to form an eye as shown in FIG. 11B.

The small shaft or pin shown in FIG. 11C is made by first forming the end of a ⅜-inch tin metal strip a scant two turns around a 5d nail. Then with your pliers make the tube or pin as round as possible on the nail.

To assemble the connecting rod first place the two formed long strips together so there will be an eye at each end of the assembly. Then place and twist a band of a 1/16-inch non-soldering metal strip around the assembly near each end as shown in FIG. 11D. Next insert the small tube pin or shaft into the eye at one end of the rod assembly and so that its end is even with the edge of the eye. Be sure that the shaft fits the eye so snugly that it will not fall out while being soldered or when given a quick shake to remove the excess solder. The rod can be soldered either by immersing it in melted solder or by applying the solder in an alcohol flame.

After the connecting rod has been soldered and the non-soldering metal bands removed, the small shaft at one end of the rod is inserted into the bearing at the end of the walking beam and the bearing at the other end of the rod is slipped over the crank pin.

The connecting rod shaft and bearing are held in place with keys such as the one described and shown in FIG. 10H.

The piston and piston rod are made into one piece as shown in FIG. 12A. It consists of a ¼-inch (¾-inch O.D.) plated washer, a tin metal bushing for the hole in the washer, a tin metal tube for the piston rod and a short tin metal tube for the small shaft.

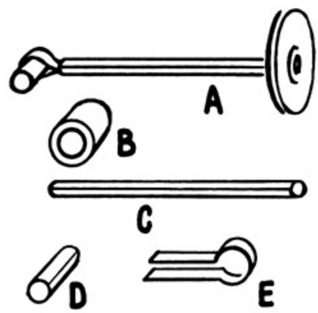


Fig. 12

The tin metal bushing for the hole in the washer is shown in FIG. 12B. It is made by first forming a ¼″ x 5″ tin metal strip on an 8d nail. The bushing is then rolled in one direction on a flat surface as shown in FIG. 9. If the bushing is a little too large the outer end of the strip can be cut away until the bushing fits snugly into the hole in the washer.

The piston rod, shown in FIG. 12C, is made by first forming the end of a 1½-inch lightweight tin metal strip a scant two turns around a 5d nail. Then cut away the surplus strip and with your pliers make the tube rod as round as possible on the 5d nail. The shaft or pin shown in FIG. 12D is a small tube formed and made the same as the piston rod except that it is made from a 5/16-inch lightweight tin metal strip.

The eye that holds the small shaft to the piston rod is shown in FIG. 12E. It is made by first folding a 1/16″ x 2″ tin metal strip at its middle and then again at its middle over an 8d nail. Then with your pliers pinch the two legs of the strip together close to the nail.

To assemble the piston and piston rod first file and clean the ¼-inch washer. Then fit the bushing snugly into the hole in the washer and so that it is even at one end. The next step is to fit one end of the piston rod into the hole in the

bushing. If necessary, the end of the piston rod can be expanded with the tapered handle end of a small file so it will fit snugly into the hole in the bushing. Then fit the formed eye into the other end of the rod and the small shaft into the eye. Pinch the eyes lightly to make the shaft fit snugly. You next make the small shaft extend out at one end just far enough to go through the bearings at the ends of the walking beam. The piston rod assembly can best be soldered by applying the wire solder in an alcohol flame.

Fig. 13

The next part of the engine to make is the cylinder assembly shown in FIG. 13. It consists of the cylinder, steam chest or drum and the cylinder head. To form the cylinder first cut from lightweight tin metal a strip 1¼″ x 5½″. At one end of this strip from about ½ inch in file the end of the strip to a sharp knife edge as shown in FIG. 14A.

You next form the tin metal strip around a ⅝-inch cylinder and so that the sharpened end will be on the inside of the metal cylinder. Next roll the formed cylinder on a ¾-inch cylinder as was shown in FIG. 9. Then place a black iron wire band around the cylinder near each end as shown in FIG. 14B. Tighten the bands to reduce the size of the cylinder to where the piston assembly will just barely move through the cylinder by its own weight.

You next apply soldering paste to the inside and outside end of the metal strip and then solder the cylinder either by immersing it in melted solder or by applying wire solder to it in an alcohol flame. After the cylinder has

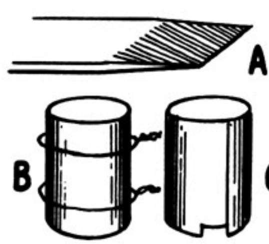


Fig. 14

been soldered file out at the bottom of the cylinder a section ⅛ inch deep and ¼ inch wide as shown in Fig. 14C.

Since it is best to fit the steam chest to the piston of the slide valve, you will make the slide valve assembly shown in Fig. 15D next. The valve piston is a strip of lightweight tin metal (soup can) 3/16″ x 3½″. First lay the strip of metal against a flat narrow piece of wood and from ½ inch in at one end file the end of the strip to a sharp knife edge as shown in Fig. 14A. Then form and roll the metal strip around an 8d nail so that the filed end will be on the outside. Around the small drum formed, tighten a band of black iron wire as shown in Fig. 15A.

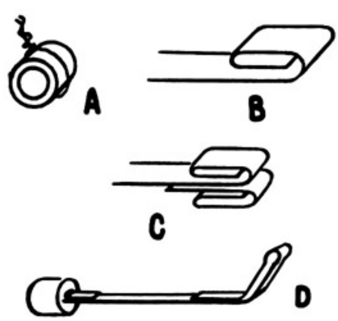


Fig. 15

The valve rod is a strip of lightweight tin metal 1/16″ x 5″. At both ends of this strip, 3/16 inch in, fold the strip two times as shown in Fig. 15B. Then ½ inch in at one end cut the strip to get the short piece that is backed against the other end as shown in Fig. 15C. Next insert the double end into the hole in the piston, 15A. Then apply the soldering paste and solder the assembly in an alcohol flame.

The next step is to use a knife blade to scrape the surface of the piston to remove all excess solder. Then file away slightly the sharp edges of the piston so it will not catch in the steam chest. The overall length of the valve and valve rod is 2¾ inches. At that length fold the valve rod. Then into the fold place a section of a wire paper clip and with your pliers pinch the two legs of the fold shut to form an eye. Then ¼ inch in from the eye bend the valve rod to almost a right angle as shown in Fig. 15D. A slight change in this bend may help to time the engine.

To form the steam chest first cut from lightweight tin metal a strip 2 inches wide. Then place one end of the strip at the end of a piece of board and from ½ inch in file the end of the strip to a sharp knife edge as shown in FIG. 14A. At 1¾ inches in from the sharp edge cut the strip to get the piece of metal for the steam chest. Next form and roll the metal piece the long way around a 40d nail or ¼-inch cylinder and so that the sharpened edge will be on the inside of the tube you form.

Then place a black iron wire band near each end of the tube as shown in FIG. 16 and with the valve piston inside the tube, tighten the bands until the valve assembly barely moves or falls through the tube by its own weight. The next step is to apply soldering paste to the outer and inner end of the metal strip in the tube and then solder the tube either by immersing it in melted solder or by applying the wire solder in an alcohol flame. In either case while the tube is hot be sure to give it a few quick shakes to remove the excess solder.

Fig. 16

At ¾ inch in from one end of the tube you next file a 1/16″ x ¼″ hole across the tube as shown in FIG. 16. With a 40d nail cut off square you can clean out the excess solder and the burr around the hole on the inside of the tube. It is necessary that the inside of the tube be completely cleaned so that the valve piston can slide back and forth past the opening quite easily.

The cylinder head is the last piece of the cylinder assembly to be made. You first cut a piece of tin metal 1″ x 2″. Then lay out the piece of tin metal as shown in FIG. 17A. First draw a dotted line across the middle of the metal piece. Then at ⅜ inch to the right and left of the middle line draw dotted lines parallel to the middle line. On the left hand por-

tion of the piece, ⅜ inch in from both long edges, draw two full lines from the end of the piece to the dotted middle line and parallel to the long sides of the metal piece.

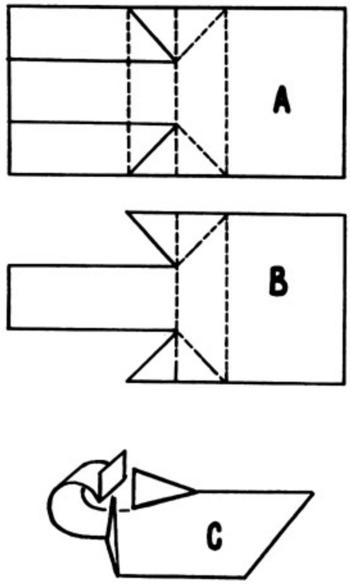


Fig. 17

Then from the point where the upper full line intersects the dotted middle line draw a dotted line up to the right and a full line up to the left to where the two vertical dotted lines meet the upper long edge of the piece of metal. Then repeat the same steps for the lower portion of the metal piece except you draw the lines downward to the lower edge as shown in Fig. 17A.

You now cut into the metal piece on all full lines so as to make the piece appear as shown in Fig. 17B. Then on the two oblique dotted lines bend up the two side portions to right angles as shown in Fig. 17C. The central tail-like portion of the piece is then formed around the steam chest and is shaped as shown in Fig. 17C.

Fig. 18

The first step in joining the parts of the cylinder assembly is to assemble the steam chest and cylinder head as shown in Fig. 18. Be sure that the hole in the steam chest opens towards the cylinder and that the short end of the steam chest points to the right which is towards the crank in the engine

assembly. Also be sure to have the iron wire bands around the ends of the steam chest while soldering.

To hold the steam chest fixed to the cylinder head, and to cover some openings between the two, cut three tin metal strips about 1/32″ x 3″ and place them scarf-like around the neck between the two members. Then twist the ends of the strips together underneath the assembly. These ends will be twisted off and filed smooth when the whole assembly is finished.

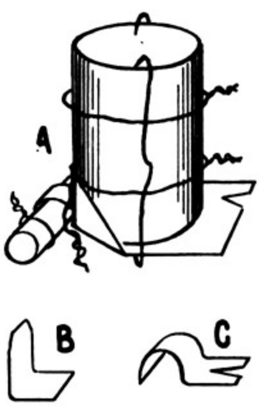


Fig. 19

The next step is to add the engine cylinder to the head and steam chest as shown in Fig. 19A. First see that the cylinder has its two iron wire bands. Then add the cylinder so that the filed-out section at the bottom will face the hole in the steam chest. Then loosen and adjust the lower wire band on the cylinder so that it will include the end of the tail projection and the two upward projections of the cylinder head. After the adjustment the wire band is again tightened.

You next make a hook at one end of a 4½-inch length of black iron wire. Place the hook into the open end of the cylinder and bring the wire down around the head and back up into the open end of the cylinder on the opposite side as shown in Fig. 19A. With your pliers kink the wire band on both sides of the cylinder to bring the head up against the cylinder.

After checking to see that the steam chest is properly aligned and that the head does not gap away from the cylinder, you apply soldering paste and then apply the wire solder in an alcohol flame. While the assembly is cooling hold it vertically to allow more solder to form around the

head and cylinder. After the assembly has cooled it is cleaned and finished with a V cut for the screw near the corner in the outer edge of the head as shown in FIG. 19A.

The next step is to add the cylinder assembly to its position on the engine base. To help hold the assembly in place requires a clamp or strap over the inner end of the steam chest. This clamp or strap is a tin metal strip ⅜" x ¾" formed as shown in FIG. 19C. First at ¼ inch in from one end of the ⅜" x ¾" piece bend the metal strip to a right angle as shown in FIG. 19B. Then snip away slightly the two corners of the longer end.

You next set the longer end of the strap against a ¼-inch cylinder and form this end over the cylinder so it will appear as shown in FIG. 19C. Then into the short end of the strap make a V cut for the screw that fastens the strap to the engine base.

The cylinder assembly is now ready to be added to the engine base. First place the piston assembly into the cylinder assembly. Then slip the V cut in the cylinder head under the screw head in the base. Next add the tin metal strap over the inner end of the steam chest and tighten both wood screws.

You now insert the small shaft at the end of the piston rod into its bearing in the end of the walking beam. This small shaft is held in its place with a key the same as the one described and shown in FIG. 10H.

The valve rod guide and timer consists of the guide and a bearing as shown in FIG. 20C. The guide is made by forming a straightened wire paper clip as shown in FIG. 20A. Use your pliers to make the four bends sharply and to right angles. First at ⅜ inch in from one end of the wire make the first

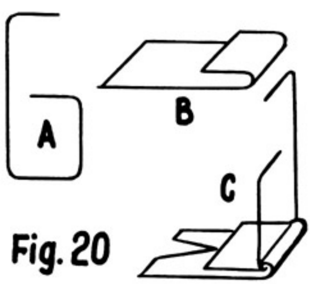


Fig. 20

bend. Then ½ inch from the first bend make the second bend. The third bend is ⅜ inch from the second bend and the fourth bend is 1 inch from the third bend. At ⅜ inch from the fourth bend cut away the surplus wire.

To make the bearing you first fold a ⅜″ x ¾″ tin metal strip ¼ inch in from one end as shown in FIG. 20B. Then slip the lower closed section of the guide into the fold and with your pliers pinch the legs of the fold close to the guide section to make the bearing. You next make the V cut for the screw at the opposite end of the bearing piece and then add the valve guide to its position at the middle of the engine base.

The piston of the valve rod is now inserted into the steam chest and the small bearing at the other end of the valve rod is slipped over the middle open section of the valve rod guide.

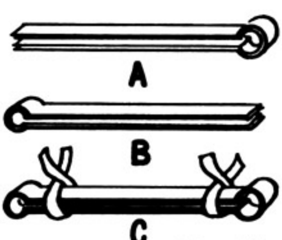


Fig. 21

The eccentric rod which connects the valve rod guide to the crank is shown in FIG. 21. To make the eccentric rod you first cut four 1/16″ x 3″ tin metal strips. Then place two of the strips together and form them at their middle over an 8d nail. With your pliers pinch the legs of the strips together close to the nail to form the larger eye or bearing shown in FIG. 21A. You next place the two other 1/16″ x 3″ metal strips together and fold them at their middle. Then place into the fold the upper open section of the valve rod guide and with your pliers pinch the legs of the strips together close to the guide section to form the smaller eye or bearing shown in FIG. 21B.

The next step is to solder together the two parts formed. First place the two parts together so there will be a bearing at each end of the assembly. To hold the parts in place while

soldering, place 1/16-inch non-soldering metal bands near the ends as shown in FIG. 21C.

Next make the distance between the bearing centers 1½ inches and then solder the assembly either by immersing it in melted solder or by applying wire solder in an alcohol flame. In either case give the assembly a quick shake to remove the excess solder. After removing the bands the eccentric rod is finished. The small bearing at one end of the eccentric rod is slipped over the upper section of the valve rod guide and the larger bearing at the other end of the eccentric rod is slipped over the crank pin.

The last part of the engine to make is the flywheel shown in FIG. 22. To make the flywheel the first step is to cut all the necessary tin metal strips. The two longer strips for the rim sections are ½″ x 15″. They are cut from metal obtained from a Crisco can or a one-pound coffee can. The paint on the strips from the coffee can can best be scraped off with a jackknife. All remaining strips can be cut from any clean tin can.

Fig. 22

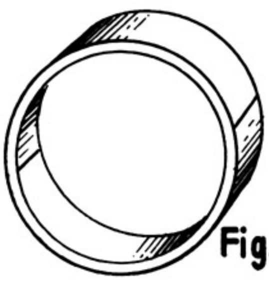


Fig. 23

The two tin metal strips for forming the spokes are ⅛″ x 12″ and the tin metal strip for the inner hub is ½″ x 3″. Two tin metal strips 3/16″ x 4″ are needed for the two collars that go over the ends of the inner hub. Then cut two tin metal strips for the two jigs that are used in forming the spokes. One strip is ¾″ x 8″ and the other is ⅛″ x 8″

The first strips to form are the two ½″ x 15″. Form and roll these strips separately on a 1¼-inch cylinder such as a large flashlight cell or an Alka-Seltzer bottle to make the two rim sections as shown in FIG. 23.

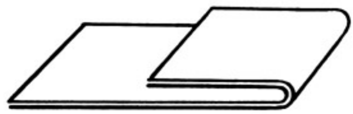


Fig. 24

To form the spokes you must first make the two jigs shaped as shown in FIG. 24. First fold the ¾″ x 8″ strip at its middle and with your pliers pinch the fold shut. Then again fold the metal piece at its middle and again pinch the fold shut. At ⅜ inch in from the end with the last fold use your pliers to make a fold. Into this fold place three strips of tin metal for the proper size opening and then pinch the fold shut. For the second jig repeat the same for the ⅛″ x 8″ strip. If the folded end of this jig is more than ⅛ inch wide it should be filed down to ⅛ inch or less.

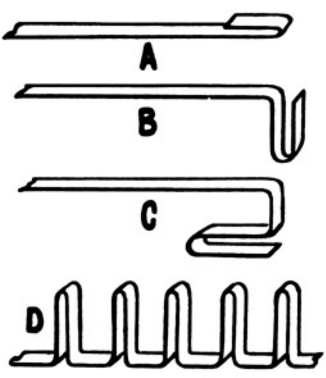


Fig. 25

To form the spoke assembly you first make the two ⅛″ x 12″ tin metal strips even at one end. Then place the even end into the fold of the larger jig so that the ends of the strips are even with the side of the jig. Next bend the metal strips over the edge of the jig to make a fold as shown in FIG. 25A. Now move the jig to the longer leg of the strips and bend the strips to a right angle as shown in FIG. 25B. Next place the smaller jig across the strips close to the last bend and again bend the strips to a right angle as shown in FIG. 25C.

Now again use the larger jig to make another fold and another right angle bend as you did before. Then continue the process of making folds with the larger jig and spacing them with the smaller jig as shown in Fig. 25D. When you have six folds or spokes cut the strips even with the last space.

The next step is to separate the two formed metal strips and again mesh them one fold to the right. With your pliers pinch all the folds shut except the two single folds at the ends of the assembly. Then spread the outer ends of the spokes until they form a circle as shown in Fig. 26. Now mesh the two single folds and pinch them shut also.

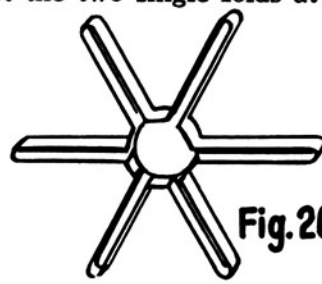


Fig. 26

The next step is to add a small clamp or band around each spoke at the hub to hold it together and in place. First cut six 1/16″ x ½″ tin metal strips. Then at one end of each little strip make a hook as shown in Fig. 27A. Next form the small metal strip around the spoke and slide it into the hub as shown in Fig. 27B. Then with your pliers pinch the band to make it stay in place. Now solder the spoke assembly either by immersing it in melted solder or by applying wire solder to it in an alcohol flame.

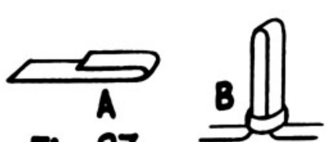


Fig. 27

To make the hub of the flywheel first form and roll the ½″ x 3″ tin metal strip on a ¼-inch cylinder to make the inner drum shown in Fig. 28A. Then on the same ¼-inch cylinder form and roll the two 3/16″ x 3″ tin metal strips to make the two collars as shown in Fig. 28B.

Fig. 28

Fig. 29

The next step is to assemble the parts of the flywheel. First use a mandrel (tapered tool) to make round the center of the spoke assembly. Then insert into the center the inner drum of the hub so as to fit the center snugly. Next expand the two collars so they will fit snugly over the ends of the inner drum.

By pushing against the inner end of the metal strip in a rim section the section can be expanded until it will slip over the outer ends of the spokes. Then expand the second rim section and slip it over the first rim section.

The next step is to tighten a black iron wire band around the rim of the flywheel assembly. Then place the assembly flat down on a flat surface and push down against all the parts to align them properly and so that the flywheel will run true.

The flywheel assembly can be soldered either by immersing it in melted solder or by applying wire solder in an alcohol flame. While the assembly is still hot the excess solder on the outer rim can be wiped or brushed off with a cloth or brush.

Fig. 30

To mount the flywheel onto the crankshaft requires first a sleeve as shown in Fig. 30A. This sleeve is a piece of tin metal ½″ x ¾″ formed the long way around the crankshaft or an 8d nail and so that the sleeve has a slight opening. Without the nail inside squeeze the sleeve slightly to make it fit the crankshaft snugly.

Then over the sleeve at its middle as shown in Fig. 30B, wind and roll enough turns of a ½-inch strip of mechanical drawing paper to make a drum that will fit snugly into the hub of the flywheel. Next slip the crankshaft through the

metal sleeve to the proper position and then return the crankshaft to its bearings on the engine base.

When all the parts of the engine are properly assembled, linked and keyed together, the engine is ready to operate. First see that all the bearings and parts are oiled so they will operate quite freely. Then by blowing into the steam chest you can tell how much change in the valve timing is necessary. Timing the valve of the engine is done in two ways. First by bending the middle open section of the valve rod guide either towards the steam chest or away from the steam chest and then by changing the amount of bend in the angle at the outer end of the valve rod. One should make these adjustments only a little each time until the engine operates at its best.

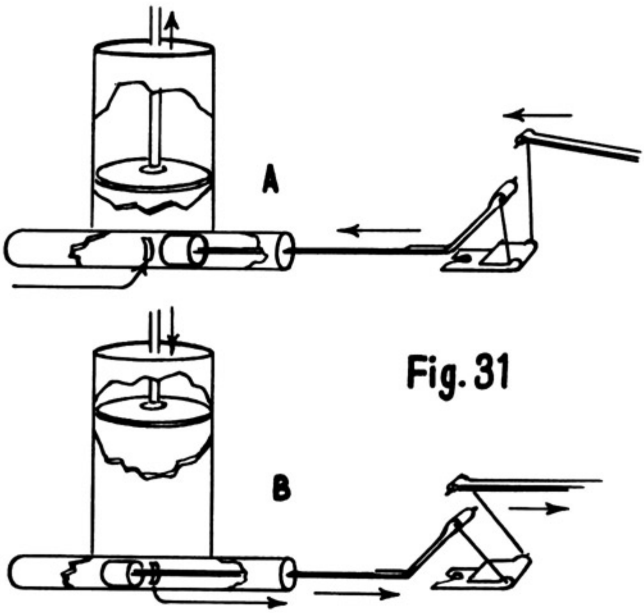


Fig. 31

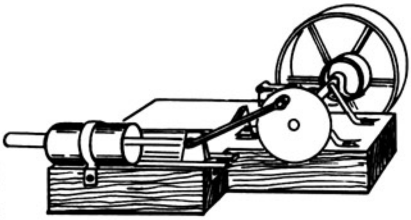
FIG. 31 shows the working operation of the various parts of the walking beam engine. In FIG. 31A the cut away sections show the relative positions of the cylinder piston and

the slide valve when the steam enters the cylinder to produce the motion that is shown by the three arrows.

In FIG. 31B the slide valve has moved past the opening (port hole) leading into the cylinder and thereby shut off the steam. At the same time the port hole is opened into the other end of the steam chest and thereby permits the steam in the cylinder to escape and to make the engine ready for the next cycle. By the reversed action of the eccentric rod the slide valve again is moved so as to open the port hole for steam to enter the cylinder and thereby start the next cycle.

Section IV

THE CROSSHEAD ENGINE



AN 1860 MODEL

HOW TO BUILD A CROSSHEAD STEAM ENGINE

The crosshead type steam engine came into use about 1860. It makes use of a crosshead to eliminate the walking beam used in the early steam engines.

For the sake of simplicity the crosshead engine described here is a single stroke engine. This means that it has only one power stroke for each revolution.

To build this engine gives one a great deal of information and experience with engines, especially in regard to timing and valve action. This engine is also designed to operate on a low pressure such as one's own lung pressure.

Building this crosshead engine requires no skill and needs only a few simple tools such as an inexpensive tin snip, a pair of pliers, a 6-inch three-cornered file, a hack saw blade and an alcohol lamp for soldering.

A few materials that one will need for building this and similar projects are a coil of lightweight black stove pipe wire and an assortment of common nails. The assortment of nails should consist of four or five of each kind of nail and vary in size from 4d to 40d.

Also one should have a 5- or 6-inch length of ⅜, ½ and ⅝-inch dowel stock and several sizes of empty thread spools. Then, too, for soldering one will need some soldering paste and plain wire solder.

In addition to the above list of materials one will need for this project a piece of ¾-inch soft wood, a clean cut ¼-inch (size of hole) washer, about one dozen ¼-inch No. 3 round-headed screws and tin can metal.

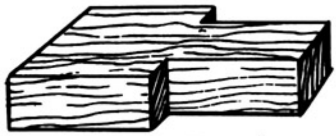


Fig. 1

The first part of the cross-head engine to make is the base shown in FIG. 1. First cut from a piece of ¾-inch soft wood a block 2½" x 5". On this block draw a line across the middle. From this middle line to the right draw lines ½ inch in from the two long edges. On these two lines saw in from the end as far as the middle line and then saw in on the middle line to cut away the two corners as shown in FIG. 1. The next step is to sand-paper the base thoroughly and apply a coat of black shellac or a coat of some other paint.

The simplest way to locate the screw spots on the engine base is to make a templet as shown in FIG. 2. On this templet at the narrow end draw a line ¼ inch in from each side. On these lines ¾ inch in from the narrow end make short cross lines. Then one inch farther in on the same lines draw another pair of short cross lines. These short cross lines indicate where the screws will be for holding the crankshaft bearing supports.

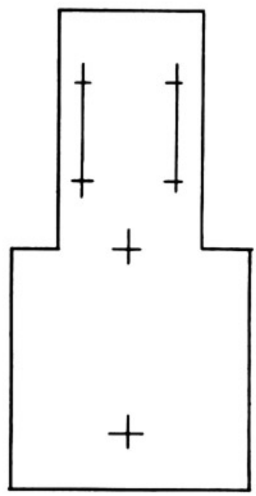


Fig. 2

At the exact center of the templet draw a pair of short cross lines to show where the screw will be that will hold the bearing or hinge for the eccentric rod guide and timing adjustment.

Then at ⅝ inch in from the wide end of the templet and at the middle of the templet draw a pair of short cross lines to show where the screw will be that will hold the cylinder strap.

To use the templet lay it properly over the engine base and with a sharp-pointed object punch through the paper templet into the engine base at all the short cross lines. This will locate the screw spots on the engine base.

Into each screw spot on the engine base screw in almost all the way a ¼-inch No. 2 or No. 3 round-headed screw. Also in the middle of the front side of the base, ⅝ inch in from the end of the base, locate and place a small round-headed screw. This will complete the base and make it ready to receive the several parts as they are completed.

The next part of the engine to be made are the two shaft bearings and bearing supports. They are the simple type made by forming two ⅜″ x 2¼″ tin metal strips as shown in FIG. 3. This bearing has the advantage that it can be opened and closed again after receiving the shaft.

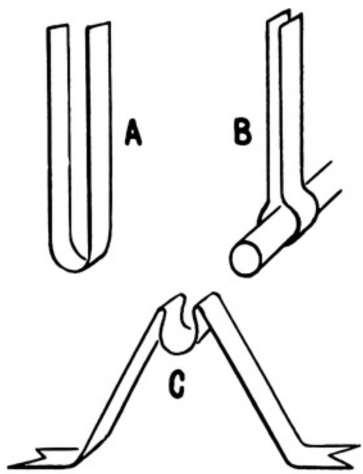


Fig. 3

First fold the ⅜″ x 2¼″ strips at their middle over an 8d nail to form a U as shown in FIG. 3A. Then with your pliers pinch the legs of the U together close to the nail as shown in FIG. 3B. Now place two or more turns of string around the metal legs close to the nail and then bend the legs outward and around so that they will point in the opposite direction. Next remove the string.

The feet are formed by bending the ends of the support legs outward from ¼ inch in from the end. To receive the screws that hold the supports to the engine base you either cut V slots in the feet with your tin snip or place the feet on the end grain of a piece of wood and punch a hole with an

8d nail cut off square. The finished bearing and support is shown in FIG. 3C. The advantage of this bearing and support is that it is very adjustable. The next step is to add the two bearing supports to the engine base.

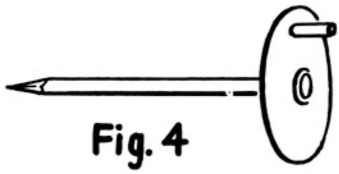


Fig. 4

The crankshaft assembly is shown in FIG. 4. It consists of an 8d nail with its head cut away for a shaft, a crank pin, a crank disk and a bushing.

The crank disk is made by first cutting from tin can metal a 1¼-inch square. On this square draw the diagonals to locate the center as shown in FIG. 5A by the dotted lines. On one of the diagonals measure out from the center ½ inch to locate the center for the crank pin. Then with a sharp pointed nail dent the center of the disk and also the center for the crank pin. Now set your compass to a ⅝-inch radius and draw the circle shown in FIG. 5A.

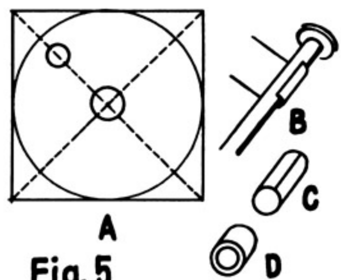


Fig. 5

Now with your tin snips cut away first the four corners of the square up to the circle line. Then cut away the eight new corners up to the circle line. Now with a file you can remove the small new corners to make the disk round.

The next step is to place the crank disk on the end grain of a piece of wood and with a 30d nail cut off square and a hammer punch out a hole at the disk center. Strike the nail gently the first blow so you can check to see if the hole is at the center. The second blow should be hard enough to punch out the hole. Then use a 6d nail to punch the hole for the crank pin.

The crank pin is a small metal tube, 5C, made by forming a scant two turns of a ¼-inch lightweight tin metal strip around a 5d nail as shown in FIG. 5B. After cutting away the surplus tin metal strip use your pliers to make the tube as round as possible with the 5d nail inside. If necessary, use the tapered handled end of a small file to ream out the hole in the crank disk so the crank pin will fit the hole quite snugly.

The bushing shown in FIG. 5D is a tin metal strip 3/16″ x 1½″. First form the tin metal strip around an 8d nail. Then to make the bushing solid and round place it with the 8d nail inside on a piece of board and with a narrow piece of board roll the bushing in one direction only as shown in FIG. 6.

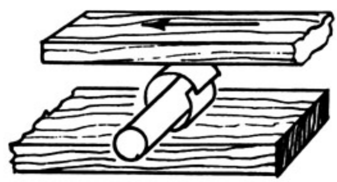


Fig. 6

The next step is to first file the metal clean around the blunt end of an 8d nail with its head cut away. Then insert the blunt end into the bushing in the crank disk and if necessary key the shaft nail in place with a tapering sharp piece of tin metal.

When all the parts of the crankshaft assembly have been adjusted to their proper position as shown in FIG. 4, you add the soldering paste and apply the wire solder in an alcohol flame. Then when the assembly has cooled the shaft is placed in its bearings on the engine base.

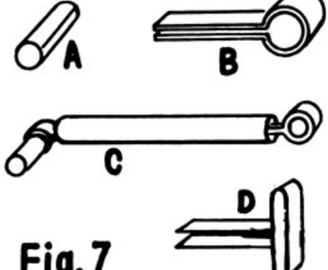


Fig. 7

The connecting rod that connects the crank to the crosshead is shown in FIG. 7C. The small short shaft, 7A, is a small tube made by forming a scant two turns of a ¼-inch lightweight tin metal strip around a 5d nail. After cutting

away the surplus strip the formed tube can be made true and round by rolling it with the nail inside as shown in FIG. 6.

The connecting rod itself is also a tube made by forming a scant two turns of a 1½-inch lightweight tin metal strip around a 5d nail. After cutting away the surplus strip the tube or rod can best be made straight and round by rolling it with the nail inside as shown in FIG. 6.

The bearing at one end of the connecting rod is made by first folding at its middle a 1/16″ x 6″ tin metal strip. Then fold the double strip at its middle to form a U. Into the U place an 8d nail and with your pliers pinch the legs of the U close to the nail to form an eye as shown in FIG. 7B. Then insert the legs of the eye into the connecting rod tube and the eye will be the bearing at that end of the connecting rod.

To hold the small shaft tube at the other end of the connecting rod make another eye as before except for this one use the small tube shaft (FIG. 7A) in place of the 8d nail when pinching the metal legs of the U together. You next make one end of the tube shaft even with one side of the eye and then insert the metal legs of the eye into the other end of the connecting rod tube to complete the connecting rod assembly as shown in FIG. 7C. Now apply soldering paste to the rod assembly and then apply the wire solder in an alcohol flame.

To hold the connecting rod in place on the crank pin requires a split key as shown in FIG. 7D. It is a 1/16″ x 1¼″ tin metal strip. First fold and form the metal strip over an 8d nail to make an eye as shown in FIG. 7B. Then remove the 8d nail and hold the formed strip with your pliers against the eye. Now use a hammer to flatten the eye in against the pliers to complete the key as shown in FIG. 7D.

The crosshead is shown in FIG. 8C. First fold a ½″ x 1½″ tin metal strip at its middle as shown in FIG. 8A and with

your pliers pinch the fold completely shut. From ⅛ inch in from the sides at the folded end of the metal piece cut away the sides to taper the piece as shown by the dotted lines in FIG. 8B. The taper extends to ¼ inch in from the open end.

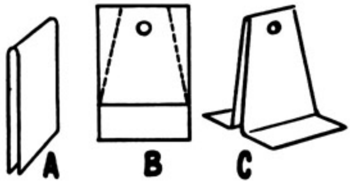


Fig. 8

In the middle at the folded end of the metal piece and 3/16 inch in from the fold, use a pointed 6d nail to punch a hole. Then file away the burr raised by the nail and with the tapered handle end of a small file ream out and enlarge the hole until the end shaft in the connecting rod will pass through it.

The next step is to bend outward to a right angle the two sides of the crosshead at their open end as shown in FIG. 8C. The sides are bent sharply 3/16 inch in from their open end. With a file round slightly the four corners at the open end to prevent them from holding the crosshead in the guide.

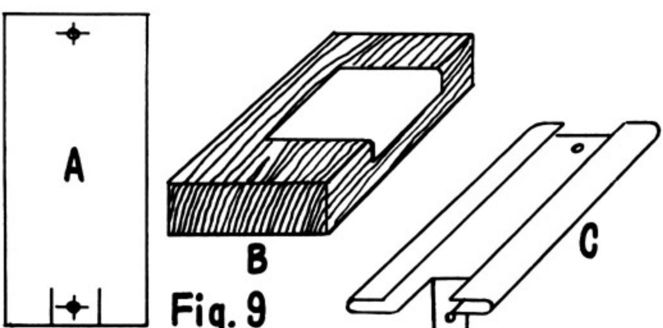


Fig. 9

The crosshead guide shown in FIG. 9 is a piece of tin can metal ¾″ x 1½″. At 3/16 inch in from both ends and in the middle of the piece as shown in FIG. 9A use a pointed nail to punch the two small holes for the small nails that will hold

the guide to the engine base. Then at one end of the metal piece, ¼ inch in from each side make cuts ⅜ inch deep with your tin snips.

The next step is to lay the piece of metal over a sharp corner so that one long side extends evenly over the corner ⅛ inch. Then with a hammer bend the extended portion down against the block to a right angle as shown in FIG. 9B. To insure the correct thickness of the fold place first against the right angle a jig consisting of three pieces of tin metal ½ inch wide and about 2 inches long. Then fold the right angle in onto the jig.

Now fold the other side of the metal piece in over the jig and with your pliers complete closing the two folds shut down against the jig. Then pass the point of a knife blade between the folds and the jig to release the tension so the jig can be pulled out a piece at a time.

The next step is to bend down to a right angle the tongue between the two ⅜-inch cuts to complete the guide as shown in FIG. 9C. The guide is then fastened to the engine base with two ½-inch wire nails and so that it will be even with the outer edge of the engine base.

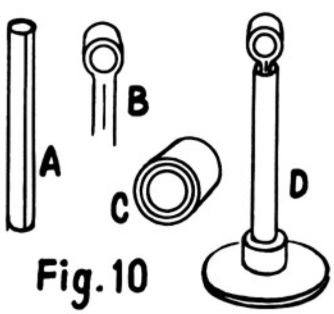


Fig. 10

The piston and piston rod are shown in FIG. 10. The piston is a clean cut ¼-inch (size of hole) plated washer and the piston rod is a tube, 10A, made by forming a scant two turns of a 1¼-inch lightweight tin metal around a 6d nail in the same manner that you made the connecting rod. The eye or bearing, 10B, at one end of the tube rod is also made the same as the bearing in the connecting rod. The cut washer must be scraped and cleaned around its hole so it will take solder.

The bushing, 10C, which is needed to fit the piston rod to the hole in the washer, is a tin metal strip 3/16″ x 4½″. First form the metal strip around a 6d nail. Then by turning the tapered handle end of a small file in the hole of the bushing you can expand the bushing until it fits the washer hole quite snugly. If necessary, a small tin metal sleeve can be added to fit the piston rod snugly to the bushing. Also the piston rod tube can be expanded slightly to make it fit the hole in the bushing snugly.

In assembling the piston and piston rod as shown in FIG. 10D, make the rod, bushing and washer all even at the outer end. Then apply the soldering paste and solder the assembly in an alcohol flame. The hole in the outer end of the rod tube can best be plugged with a small ball of clean steel wool or by setting the hot assembly on a pellet of solder.

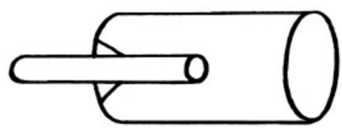


Fig. 11

The cylinder assembly shown in FIG. 11 consists of the cylinder, the cylinder head and the steam chest. The cylinder is made up of an inner and an outer sleeve as shown in FIG. 12. Since the diameter of the piston is ¾ inch its circumference will be close to 2⅜ inches. Therefore the piece of tin metal for the inner sleeve will be 1¼″ x 2⅜″.

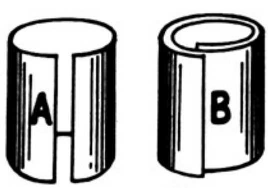


Fig. 12

First form and roll the 1¼″ x 2⅜″ piece of tin metal around a ⅝-inch cylinder. Then slip the sleeve formed over a ¾-inch cylinder and either tap the sleeve gently all around with a hammer or rub it lengthwise all around with a piece of wood. This will tend to open it as shown in FIG. 12A and form it to proper size and shape.

For the outer sleeve shown in Fig. 12B first form a 1¼" x 5" tin metal strip around a ⅝-inch cylinder and then roll the formed cylinder on a ¾-inch cylinder. Next place the inner sleeve inside the outer sleeve and then place two black iron wire bands around the assembly as shown in Fig. 13A. Tighten the wire bands until the gap or butt joint in the inner sleeve is closed. Then insert the piston to check the sleeve for size.

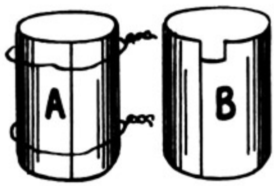


Fig. 13

If the inner sleeve is too large, slip it out and cut away a very small amount (1/32 inch) each time from one side of the gap until the piston assembly will just barely pass through the cylinder by its own weight.

When the piston fits the cylinder properly, apply soldering paste to the butt joint on the inside of the cylinder and the lap joint on the outside. Also along the edges at the ends. Then solder the cylinder either by immersing it in melted solder or by applying the wire solder in an alcohol flame.

The next step is to use a knife blade to scrape and clean away the surplus solder on the inside of the cylinder so that the piston can slide through the cylinder freely. You next file out a section ⅛ inch deep and ¼ inch wide at one end of the cylinder as shown in Fig. 13B.

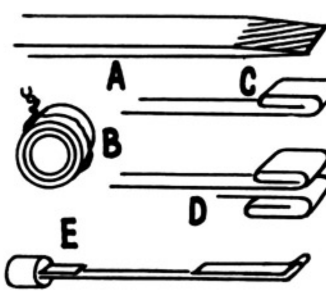


Fig. 14

Since it is best to fit the steam chest to the piston of the slide valve you will next make the slide valve assembly shown in Fig. 14E. The slide valve piston is a strip of lightweight tin metal 3/16" x 3½". First from ½ inch in from both ends of the strip file the

two ends to a sharp knife edge as shown in Fig. 14A. The filing can best be done if the metal strip is placed on a piece of board so that the end to be filed will be at the end of the board.

Now form and roll the tin metal strip around an 8d nail. Then tighten around the formed valve drum a black iron wire band as shown in Fig. 14B.

The valve rod is a strip of lightweight tin metal 1/16″ x 5″. At both ends of the metal strip 3/16 inch in, fold the strip two times as shown in Fig. 14C. Then ½ inch in at one end cut the strip to get the short piece that is backed against the other folded end as shown in Fig. 14D. Next insert this double end into the hole in the valve drum and then solder the assembly either by immersing the valve drum in melted solder or by applying wire solder to it in an alcohol flame.

The next step is to use a knife blade to scrape the surface of the valve drum or piston to remove all the excess solder. Then file away slightly the sharp edges of the piston so it will not catch in the steam chest. The overall length of the slide valve and its valve rod is 2¾ inches. At that length fold the rod and place into the fold the wire from a paper clip. Then with your pliers pinch the legs of the fold shut to form an eye. The complete slide valve and valve rod is shown in Fig. 14E.

The simplest way to form the steam chest is to first file one end of a 2-inch tin metal strip from ½ inch in to a sharp knife edge as was shown and described in Fig. 14A. Then cut the metal strip 1½ inches in from the sharpened end to make a piece 1½″ x 2″. You next form and roll the metal piece the long way on a ¼-inch cylinder (40d nail) and so that the sharpened end will be on the inside of the 2-inch tube formed.

The next step is to place a black iron wire band around each end of the steam chest as shown in Fig. 15. Then insert

into the steam chest the valve piston and tighten the two bands until the piston assembly just barely falls out by its own weight. Now apply soldering paste to both the inside and outside laps and then solder the tube either by immersing it in melted solder or by applying the wire solder in an alcohol flame. While the tube is hot give it a few quick shapes to remove the excess solder.

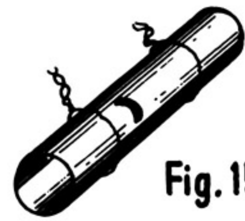


Fig. 15

The next step is to file a hole 1/16″ x ¼″ across the steam chest at its middle as shown in Fig. 15. With a 40d nail cut off square you can clean out the excess solder and the burr around the hole on the inside of the steam chest. It is quite necessary that the slide valve can move back and forth past the opening quite easily.

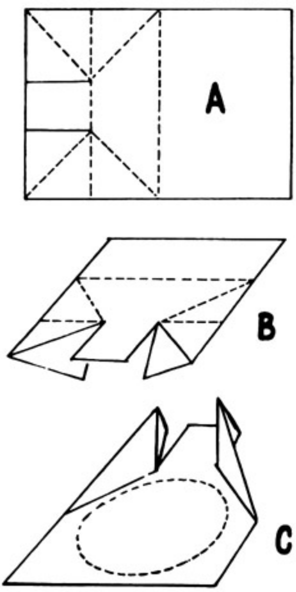


Fig. 16

The cylinder head is formed from a piece of tin metal 1″ x 1⅜″. On this piece of metal lay out the lines as shown in Fig. 16A. At ⅜ inch in from one end draw a dotted crosswise line. At ⅜ inch in from the first line draw another dotted crosswise line. Then at the same end of the piece ⅜ inch in from each long side draw solid lines as far in as the first dotted line.

From where the upper solid line meets the first dotted line draw a dotted diagonal line up to the right to where the second dotted line meets the edge of the piece. Then draw the left dotted diagonal line up to the corner of the piece.

From where the lower solid line meets the first dotted line draw the two lower dotted diagonal lines in the same manner.

With your tin snip cut into the piece on the two solid lines as far as the first dotted crosswise line. Then with your pliers bend down to a right angle on the two outer dotted diagonal lines as shown in FIG. 16B. Then on the other two dotted diagonal lines bend up to a right angle as shown in FIG. 16C. The cylinder fits into the angle formed as shown by the dotted circle. The ¼-inch projecting tongue is next bent down to a right angle to complete the cylinder head.

The first step in assembling the cylinder assembly is to add the steam chest to the cylinder head as shown in FIG. 17. First loosen one of the wire bands around the steam chest. Then slip the tongue of the cylinder head underneath the wire band and adjust the steam chest so that the hole in its middle will be between the two bent-up sections of the head. Then tighten the wire band to hold the two members in place.

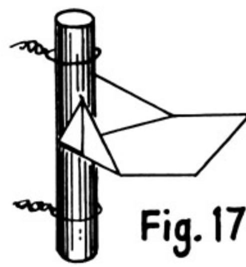


Fig. 17

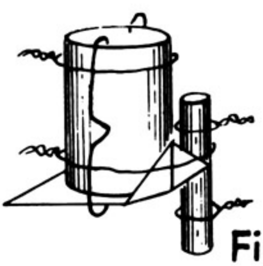


Fig. 18

Next place the cylinder against the cylinder head so that its cut-out section at the end will also be between the two bent-up sections of the cylinder head. Then tighten an iron wire band around the cylinder and steam chest as shown in FIG. 18.

You next make a hook at one end of a 4½-inch length of black iron wire. Then place the hook over the cylinder edge at the open end of the cylinder and bring the wire down around the head and back up over the edge at the open end on the opposite side. With your pliers kink the wire band

on both sides of the cylinder to bring the head up against the cylinder.

The next step is to fill the opening between the cylinder and steam chest with clean steel wool. Before putting in the steel wool, place into the opening a narrow U-shaped strip of tin metal to prevent the steel wool from going in too far.

After checking to see that the steam chest is properly aligned and that the head does not gap away from the cylinder, you apply the soldering paste and solder the whole assembly in an alcohol flame. While the assembly is cooling hold it vertically to allow more solder around the head and cylinder. After the assembly has cooled and the bands are removed the outer part of the head is cut away with a tin snip and then filed smooth and even with the cylinder.

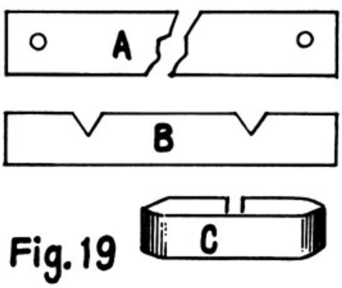


Fig. 19

To fasten the cylinder assembly to the engine base requires a metal strap and a metal support member as shown in FIG. 19. The strap is a strip of tin metal ⅜" x 3" with a hole punched ¼ inch in from each end as shown in FIG. 19A. To punch the hole place the strap on the end grain of a piece of wood and punch the hole with an 8d nail cut off square. Round the corners slightly to make the strap look finished.

The support member is a tin metal strip 5/16" x 2" with two V cuts into one long edge as shown in FIG. 19B. The cuts are made ½ inch in from each end ⅛ inch deep and ¼ inch wide. Where the cuts are made you form the strip over a ¼-inch cylinder to shape the support as shown in FIG. 19C.

To fasten the cylinder assembly to the base first put the strap loosely in its place with the ¼-inch screws. Then in-

sert the cylinder assembly under the strap and place the support member under the steam chest so that the steam chest will rest in the V cuts. Then first tighten the screw on the side of the base and then the screw on the upper surface. The cylinder head should be even with the end of the engine base.

The valve rod guide consists of the guide and a hinge bearing as shown in FIG. 20D. The guide is made by forming a straightened wire paper clip or a piece of heavy stove pipe wire. Use your pliers to make the four bends sharply and to a right angle.

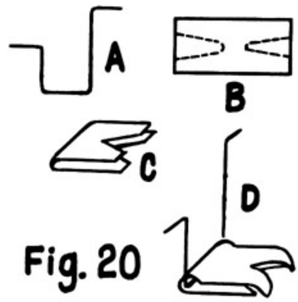


Fig. 20

First at 3/16 inch in from one end of the wire make the first bend. Then ¼ inch in from the first bend make the second bend. The third bend is ½ inch in from the second bend and the fourth bend is ½ inch in from the third bend. Then at 3/16 inch from the fourth bend cut away the surplus wire to complete the guide as shown in FIG. 20A.

To make the hinge or bearing for the guide you first make a narrow tapering U cut into both ends of a ½″ x ¾″ piece of tin metal as shown by the dotted lines in FIG. 20B. Make the cuts ¼ inch in and then twist out the metal between the cuts. Then fold the piece of tin metal at its middle as shown in FIG. 20C.

You next place the loop of the valve guide into the fold of the metal piece and with your pliers pinch the sides of the fold near the guide shut to make the bearing. Then to keep the guide bearing in proper position on the engine base use your pliers to bend down slightly to right angles the outer corners of the hinge piece as shown by the complete guide and bearing in FIG. 20D.

You next fasten the valve rod guide and bearing to the engine base with the screw that is located at the center of the engine base and so that the valve rod will be attached to the longer arm of the guide.

You now insert the slide valve into the steam chest and then slip the bearing at the outer end of the valve rod onto the projecting end of the guide.

In order that the valve rod may operate parallel to the engine base it may be necessary to make a sharp bend in it about 3/16 inch in from its eye or bearing at its outer end. This sharp bend may also be important in timing the engine.

Fig. 21

The next part of the engine to make is the flywheel shown in FIG. 21. To make the flywheel the first step is to cut all the necessary metal strips. The two longer strips for the rim sections are ½″ x 15″. They are cut from metal obtained from a Crisco can or a one-pound coffee can. The paint on the strips from the coffee can can best be scraped off with a jackknife. All other strips can be cut from any clean tin can.

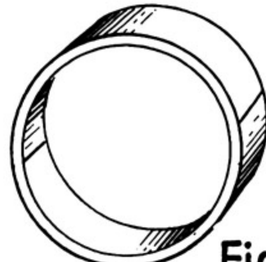


Fig. 22

The two strips for forming the spokes are ⅛″ x 12″ and the strip for the inner hub is ½″ x 3″. Two strips 3/16″ x 3″ are needed for the two collars that go over the ends of the hub. Then cut two strips for the two jigs that are used in forming the spokes. One strip is ¾″ x 8″ and the other is ⅛″ x 8″.

The first strips to form are the two ½″ x 15″. Form and roll these strips on a 1¼-inch cylinder such as a large flashlight cell or an Alka-Seltzer bottle to make the two rim sections as shown in Fig. 22.

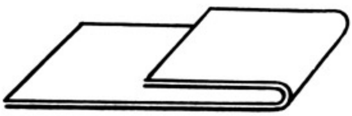


Fig. 23

To form the spoke assembly you must first make the two jigs shaped as shown in Fig. 23. First fold the ¾″ x 8″ strip at its middle and with your pliers pinch the fold shut. Then again fold the metal piece at its middle and again pinch the fold shut. At ⅜ inch in from the end with the last fold use your pliers to make another fold. Into this fold place three strips of tin metal for the proper size opening and then pinch the fold shut. For the second jig repeat the same steps for the ⅛″ x 8″ strip. If the folded end of this jig is more than ⅛ inch wide file it down to ⅛ inch.

To form the spoke assembly you first make the two ⅛″ x 12″ strips even at one end. Then place the even ends into the fold of the larger jig so that the ends of the strips are even with the side of the jig. Next bend the strips over the edge of the jig to make a fold as shown in Fig. 24A. Now move the jig to the longer leg of the strips and bend the strips to a right angle as shown in Fig. 24B. Next place the smaller jig across the strips close to the last bend and bend the strips to a right angle as shown in Fig. 24C.

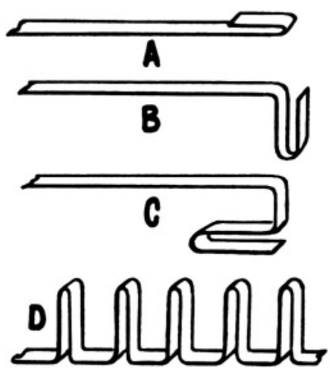


Fig. 24

Now again use the larger jig to make another fold and another right angle bend as you did before. Continue the

process of making folds with the larger jig and spacing them with the smaller jig as shown in Fig. 24D. When you have six folds or spokes cut the strips even with the last space.

The next step is to separate the two formed strips and mesh them again one fold to the right. With your pliers pinch all the folds shut except the two single folds at the ends of the assembly.

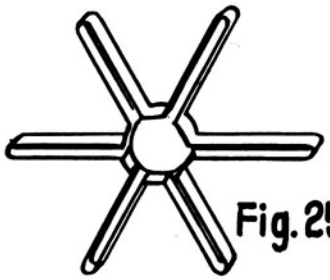


Fig. 25

You next spread the outer ends of the spokes until they form a circle. Then mesh the two single spokes and pinch them shut to complete the assembly as shown in Fig. 25.

To prevent the spokes from splitting open place a small band around each spoke at the hub. This can best be done if you first cut six 1/16″ x ½″ tin metal strips. Then at one end of each small strip make a hook as shown in Fig. 26A and form the other end of the strip around the spoke as shown in Fig. 26B. The assembly should now be soldered either by immersing it in melted solder or in an alcohol flame.

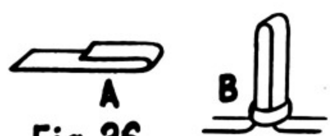


Fig. 26

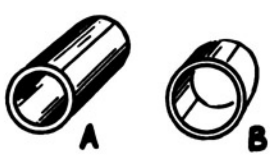


Fig. 27

To make the hub for the flywheel, first form and roll a ½″ x 3″ tin metal strip on a ¼-inch cylinder to make the inner drum shown in Fig. 27A. Then on the same ¼-inch cylinder form and roll two 3/16″ x 3″ tin metal strips to make the two collars as the one shown in Fig. 27B.

The next step is to assemble the parts of the flywheel. First use a mandrel (tapered tool) to make round the center

of the spoke assembly. Then insert the inner drum of the hub so it will fit the center opening snugly. Next expand the two collars so they will fit snugly over the ends of the inner drum.

By pushing against the inner end of the metal strip in a rim section the section can be expanded until it slips over the outer ends of the spokes. Then expand the second rim section and slip it over the first rim section.

You next tighten a black iron wire band around the rim of the flywheel assembly. Then place the assembly flat down on a flat surface and push down against all the parts to align them properly so that the flywheel will run true.

The flywheel assembly can be soldered either by immersing it in melted solder or in an alcohol flame. While the assembly is still hot the excess solder on the outer rim can be wiped or brushed off with a cloth or brush.

The eccentric shown in FIG. 28C is the engine timer. It is made as a detachable part of the flywheel and consists of a flanged rim and a sleeve by which it is fastened to the flywheel.

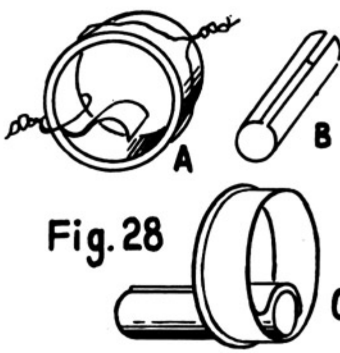


Fig. 28

The eccentric rim is a tin metal strip 3/16″ x 6″. First from ½ inch in from one end of this strip file the end to a sharp knife edge as was described and shown in FIG. 14A. Then form and roll the metal strip on a ½-inch cylinder and so that the sharpened end will be on the outside. Next place around the formed rim a band of cleaned lightweight iron or copper wire as shown in FIG. 28A. Tighten the wire band until the inside diameter of the rim is ½ inch. This wire band will later become the flange.

At about ⅜ inch in from the inner end of the strip in the eccentric rim place a temporary wire band across and around the rim as shown in FIG. 28A. This wire band will hold the rim in shape when you lift and form the inner end of the strip over a 30d nail or a 3/16-inch cylinder to make a sort of clamp. This clamp will hold the sleeve against the rim as shown in FIG. 28C.

The sleeve shown in FIG. 28B is a piece of tin metal ⅝″ x ¾″ formed the long way around a 30d nail or a 3/16-inch cylinder. This sleeve must have a small open gap on its side as shown in FIG. 28B to receive the tapering tin metal key shown in FIG. 29 and which tightens the eccentric to the flywheel.

Before adding the sleeve to the eccentric rim first lay the rim on a flat surface and push the outer wire band down against the flat surface where on the rim the band will later become the flange. Then insert one end of the sleeve between the formed clamp and the rim of the eccentric as shown in FIG. 28C and so that the edge of the rim with the wire band will be towards the outer end of the sleeve.

When the sleeve has been adjusted so it will be at right angle to the rim of the eccentric and its gap or opening is towards the center of the eccentric, apply soldering paste to where the members touch, including the wire band. Then solder the assembly either by immersing it in melted solder or by applying wire solder in an alcohol flame.

The next step is to cut away the twisted portion of the wire band around the eccentric rim. Then file down the remaining stump and make it even with wire band to complete the flange. Any excess solder on the surface of the eccentric rim should be cleaned away to complete the eccentric assembly.

The next step is to mount the eccentric and flywheel to the crankshaft. This can best be done with a tin metal sleeve

such as the one described and shown in FIG. 28B. First add the eccentric to the flywheel with a sleeve made by forming a ½″ x ⅝″ tin metal piece the short way around a 30d nail or a 3/16 inch cylinder. First expand this sleeve only enough so it will fit snugly over the eccentric sleeve. Then insert the sleeve end of the eccentric into the hub of the flywheel.

To add the crankshaft you first form a ½″ x ¾″ tin metal piece the long way around the crankshaft. If necessary make a second such sleeve and slip it over the first one. Now insert the double sleeve into the sleeve of the eccentric and then add this assembly to the crankshaft.

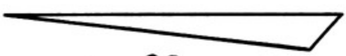


Fig. 29

The flywheel and eccentric assembly is made friction-snug to the crankshaft by means of a tapered tin metal key shown in FIG. 29. This key should be about 2 inches long, 3/16 inch at the wide end and tapered to a point.

When the pointed end of the key is inserted and pulled through the gap of the inner sleeve it will add enough metal to tighten the flywheel assembly to the crankshaft and only enough so that the eccentric can be rotated on the crankshaft for timing the engine.

When the key is in as far as necessary the two surplus ends of the key are twisted off and the stumps made smooth.

The eccentric rod and its head is made as shown in FIG. 30. It is a strip of tin metal 1/16″ x 5″. First form the middle of the strip around the eccentric rim to make the loop or head. Then place a 1/16-inch tin metal band around the two legs near the head as shown in FIG. 30A.

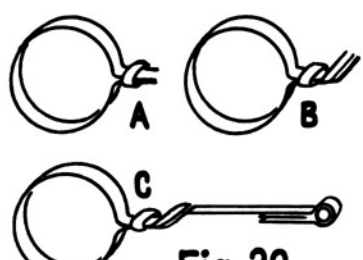
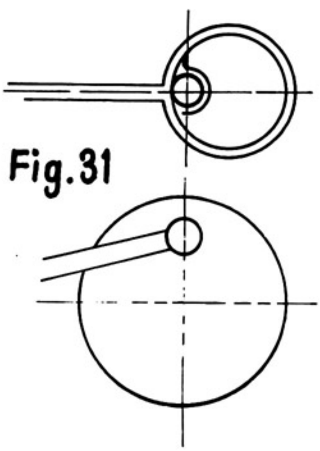


Fig. 30

With your pliers across the metal band hold the legs while you twist them sharply to a right angle bend as shown in FIG. 30B. Then with your pliers flatten the bend and adjust the legs so they are again even. Then again twist the legs to a right angle bend and so as to align the legs with the eccentric rod head as shown in FIG. 30C. This offset is needed to align the eccentric rod with the short section of the valve rod guide.

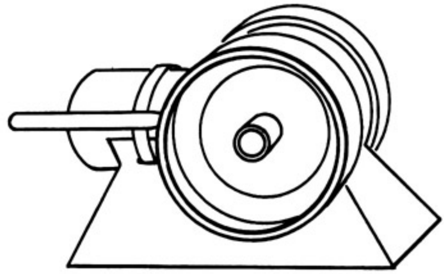
The next step is to bend and fold the legs or rod ⅞ inch from the head or loop. Into the fold place the end of the valve rod guide and with your pliers pinch the fold shut near the guide to form the eye or bearing as shown in FIG. 30C. If the eccentric rod seems too long or too short a new bearing should be made at the right place. To make the head free on the eccentric rim pass the point of a knife blade around the rim between the two members.

Fig.31



The next step is to time the engine and run it by blowing into the steam chest. The timing is quite simple as shown in FIG. 31. FIG. 31 shows the relative positions of the eccentric and the crank when the engine is timed for running clockwise. You will notice that the crank is 90 degrees ahead of the eccentric. If the crank is advanced another 180 degrees the engine will reverse and run counter-clockwise.

If the valve rod is not the exact proper length it may also be necessary to time the valve. This can be done by bending the valve rod guide arm forward or backward a very little each time until the engine runs its best.



THE INTERNAL COMBUSTION TYPE OF ENGINE

The internal combustion engine dates back to about 1880. In its construction the crosshead was eliminated by adding a skirt to the piston.

The following directions will tell how to build such an engine. This engine, however, is designed to operate on compressed air.

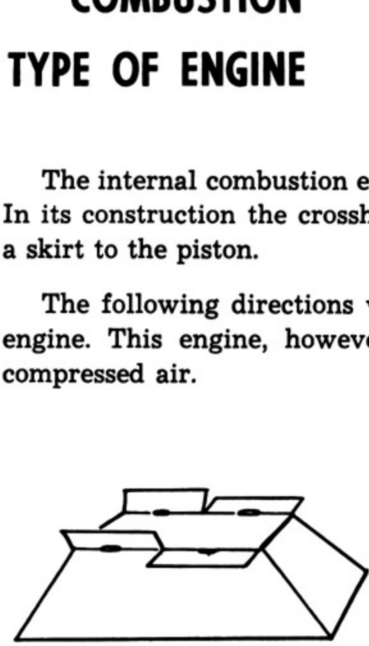


Fig. 1

The first part of the engine to make is the base as shown in Fig. 1. It is made by first forming the four sides and then joining them at the corners with solder.

In forming the four sides you will get the best results if you will use the 3/16- and ¼-inch bending jig shown in Fig. 2.

The first step is to cut from tin can metal two pieces 1½" x 3" and two pieces 1½" x 1½".

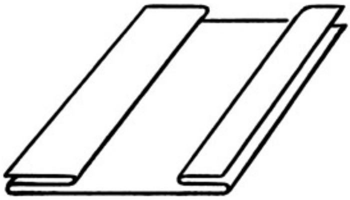


Fig. 2

In order to get all the four pieces to taper exactly the same amount it is best to mark and cut one end of a long piece and then use this tapered end as a marker or as a guide when cutting the other tapers.

Fig. 3 shows how to lay out the two long side pieces for cutting and folding. To mark for the taper first measure in on a long edge ½ inch from a corner. Then from this point draw a line to the next corner at that end as is shown by the dotted slant lines in Fig. 3. On this line cut away the end and then use this tapered end as a marker or as a guide for cutting the tapers on the other side piece and the two end pieces.

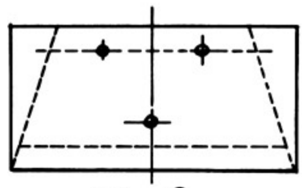


Fig. 3

The next step is to draw a cross-line at the short middle of the piece. On this middle line, ½ inch in from the lower or long edge, make a mark. On this mark use a 6d nail to punch a hole. This hole is not needed in the second long side piece. Now use the ¼-inch bending jig as a gage to mark the bending line ¼ inch in from the upper short edge and the folding line ¼ inch in from the long lower edge as shown by the horizontal dotted lines in Fig. 3.

On the upper dotted bending line, ½ inch on both sides from the middle line, make marks. On these marks use an 8d nail filed to a chisel point to punch the two oblong horizontal holes as shown in Fig. 3.

You next use your tin snip to cut in from the short edge on the middle line as far as the dotted bending line. Also at the two corners of the short edge cut in at a right angle as far as the dotted bending line. Leave the small sharp wedges

attached. They are to be bent over unto the inside and used later to hold the corner pieces when assembling the base.

The next step is to use the ¼-inch bending jig to bend the right end portion of the short upper edge towards you to a little more than a right angle as shown in FIG. 1. Then bend the left end portion of the upper edge towards you to about a half right angle. Also use the ¼-inch bending jig to fold the lower long edge inward as far as possible. Then lay the metal piece on a flat surface with the fold up and with a piece of wood stroke the fold until the fold is quite closed. The two three-cornered projections at the ends of the fold are now snipped away. The second side piece is made the same as the first except it has no round hole and it is reversed so that the left end of the short edge is bent to a little more than a right angle.

The two end pieces are formed as shown in FIG. 4. First cut the two 1½″ x 1½″ pieces so they have the same taper as the two side pieces and as is shown in FIGS. 4A and 4C. Then use the ¼-inch bending jig to fold the upper and lower edges of the front end piece as is shown in FIG. 4B. Lay the metal piece on a flat surface and with a piece of wood stroke the fold until the fold is quite closed. Then cut away the two small triangles at the ends of the fold.

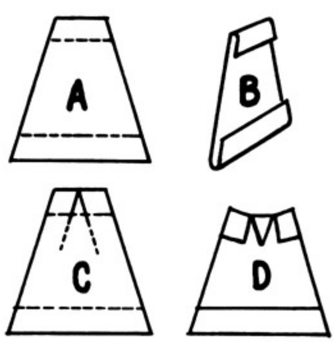


Fig. 4

Now use the ¼-inch bending jig as a gage to mark the lines ¼ inch in from the tapered edges of the back end piece as shown in FIG. 4C. Then at the narrow end of the metal piece cut in ⅜ inch on the two lines just marked.

You next fold the three sections formed inward to give the upper 'edge a rounded out

or concave effect as shown in FIG. 4D. The lower edge of the back end piece is then folded inward ¼ inch and the fold closed by stroking it with a piece of wood as before. Also cut away the two small triangles at the ends of the fold.

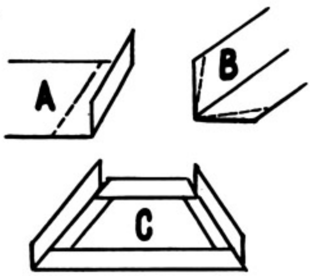


Fig. 5

The next step is to cut and bend the four angle pieces for the corners. The simplest way to do this is to use a ¼-inch bending jig to bend the end of a 1-inch tin metal strip to a right angle as shown in FIG. 5A. Then ¼ inch in from the bend as shown by the dotted line, cut away the angle piece.

To get the angle pieces to conform to the tapered side pieces when they are slipped into the folds of the end pieces it is necessary to cut away and taper the lower ends of the angle pieces as shown by the dotted lines in FIG. 5B. The taper starts about ⅛ inch in from the two lower corners and extends to the right angle bend.

You next place the four angle pieces into the folds of the two end pieces as shown in FIG. 5C. Then apply soldering paste to the parts and lay a small piece of solder along each edge of the angle pieces. Now heat the assembly in an alcohol flame until the solder disappears under the angle pieces.

The simplest way to assemble the base is to first solder an end piece to each side piece in the same manner as the angle pieces were added to the end pieces. Be sure that the right end piece is added to the proper end of the side piece. The remaining two corners can then be joined and soldered in the same manner.

The small bearing for the valve rod guide is a small tube shown in FIG. 6B. This tube is made by forming the end of a ¼ inch lightweight tin metal (soup can) strip a scant two turns around a 4d nail as shown in FIG. 6A. Then cut away the surplus metal strip and with your pliers make the tube as round as possible with the 4d nail inside.

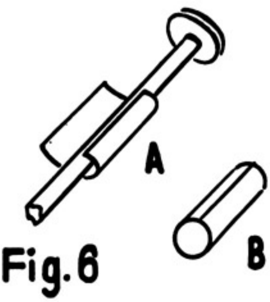


Fig. 6

The next step is to use the tapered handle end of a small file to ream and enlarge the small hole in the front side of the engine base just enough to admit the tube with a snug fit. Then insert into the tube a short piece of black stove pipe wire to prevent the tube from filling with solder while being soldered.

After adjusting the tube so it is horizontal to the base line, apply soldering paste and then heat that area just enough to flow a small amount of solder around the bearing tube.

The next part of the engine to make is the crankshaft as shown in FIG. 9B. It consists of two tubes for the shaft, one short tube for the crank pin and two loops for the throw arms. The first tube to make for the shaft is one inch long. It is made by first forming a scant two turns from the end of a 1-inch lightweight tin metal strip around an 8d nail as shown in FIG. 6A. Then cut away the surplus metal strip and roll the tube in one direc-

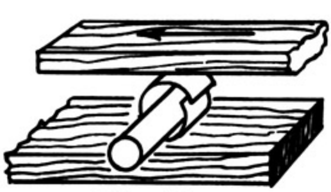


Fig. 7

tion only on a flat surface as shown in FIG. 7.

The second tube for the crankshaft is made by forming and rolling the end of a 1¼-inch strip of lightweight tin metal around an 8d nail in the exact same manner as the first tube.

The shorter tube for the crank pin is made by forming and rolling a scant two turns from the end of a ½-inch lightweight tin metal strip around an 8d nail in the exact same manner as the two tubes for the shaft. Be sure to roll the tubes as it is the rolling of the tubes that makes them true and round.

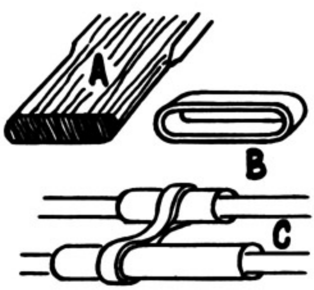


Fig. 8

The two loops for the throw arms are made from tin metal strips 1/16″ x 4½″. The jig for forming the strips into loops is shown in FIG. 8A. It is a piece of wood 3/16″ x ½″ and about two inches long, with rounded corners at one end. The start and the ending of the metal strip should be at the middle of the side. A formed loop is shown in FIG. 8B.

The next step is to place the loops over a crankshaft tube and the crank pin tube as shown in FIG. 8C. Be sure to have the 8d nails inside the two tubes. Then lay the assembly on your table and with a screw driver blade or some other object push the sides of the loops inward and together as far as possible as shown in FIG. 8C. The loops will then appear as shown in FIG. 8C.

The second crankshaft tube is now added to the proper

8d nail and a loop end is slipped over onto the tube's end as shown in Fig. 9A. To hold the sides of the loops together and add strength to the throw arms, a band is placed around the middle of the loops as shown in Fig. 9A.

The band at the middle of the loops is a very narrow tin metal strip about 1/32 inch wide and about two inches long. You first fold the metal band strip at its middle and then again at its middle to form a U. Then place the legs of the U across the middle of the loop as shown in Fig. 9A and with your pliiers twist the legs together until they are quite tight.

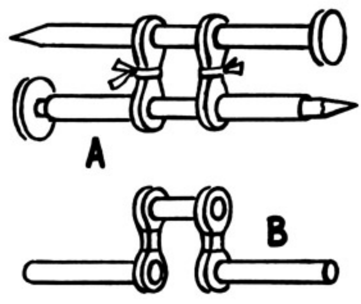


Fig. 9

Before adjusting the assembly and making it ready to be soldered, slip out the two 8d nails and apply to them a very light film of oil to prevent them from being soldered. Then place the two nails back in the assembly and adjust the parts in the assembly so that they are in place, straight and properly aligned as shown in Fig. 9A.

The next step is to apply the soldering paste and then solder the assembly in an alcohol flame. Be sure to allow plenty of solder around the two metal bands. After the crankshaft is soldered first remove the surplus of the two metal bands by using your pliers to twist them off in the same direction ts they were at first tightened. Then use a file to cut away the sharp stump that was left by the twisting. Use a knife blade to clean away any excess solder. The final step is to file down and round the outer ends of the three

strips that were used in making the three tubes. The finished crank shaft is shown in FIG. 9B.

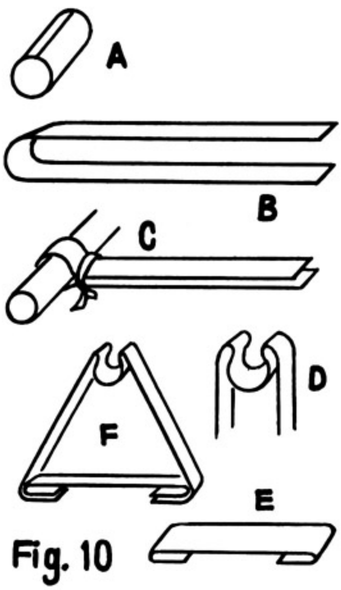


Fig. 10

You next make the two crankshaft bearings and their supports as shown in FIG. 10. The bearing shown in FIG. 10A is made by forming and rolling a 5/16″ x 1¼″ tin metal strip around a 16d nail. If the tube formed does not fit over the crankshaft it can be expanded by turning it over the tapered handle end of a file.

The bearing support is a tin metal strip ¼″ x 2½″. First bend the metal strip at its middle to form a U as shown in FIG. 10B. Hang this U over a 16d nail and with your pliers pinch the legs of the U together close to the nail. Next wind around the legs two or three turns of string close to the nail as shown in FIG. 10C. Then bend the legs of the U outward and around so they will point in the opposite direction as shown in FIG. 10D. Remove the string next and with your pliers pinch shut the two folds formed and fit the bearing (10A) into the round opening. The next step is to use a ¼-inch bending jig to bend inward to a right angle the outer ends of the legs ¼ inch in from the ends.

The lower cross piece shown in FIG. 10E is a ¼″ x 1½″ tin metal strip formed over the extended section of the front end of the engine base. You next place this cross piece between the two right angle bends of the support legs as shown in FIG. 10F.

The next step is to adjust the bearing so it is even at one end with the support legs. Then apply soldering paste to where the members will be soldered. Hold the assembly in an alcohol flame and apply a small amount of wire solder to where the parts join. To complete the bearing supports place three pieces of tin metal in the folds at the bottom and with your pliers close the folds.

The bearing supports are now added to the crankshaft with the extended portion of the bearings inward towards the crank. Then the bearing supports are slipped over the extended sections at the front of the engine base. The bearing supports are held in place by small clamps. These clamps are tin metal strips ⅛″ x ½″ slipped through the holes in the base and their ends bent over in the proper direction to do the holding.

The connecting rod shown in FIG. 11 is the next part to make. It is made by first forming the wrist pin bearing shown in FIG. 11A. This bearing is a ¼″ x 1″ tin metal strip formed and rolled around an 8d nail. The next step is to bend a ⅛″ x 2½″ tin metal strip at its middle over an 8d nail to form a U. Then with the nail inside the bearing place the bearing in the U and with your pliers pinch the legs of the U together close to the bearing as shown in FIG. 11B.

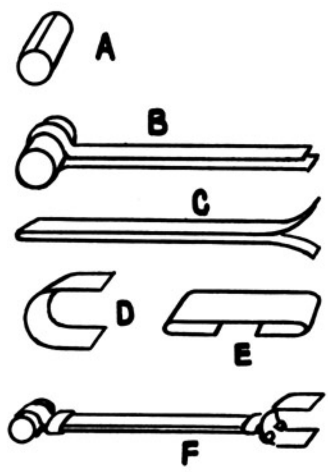


Fig. 11

The next step is to fold a ⅛″ x 2½″ tin metal strip at its middle and with your pliers pinch the fold shut. Then at ¼ inch in from the ends of the legs bend the ends outward to

about 45 degrees as shown in FIG. 11C. You next form the crank pin bearing piece. This is a ¼″ x ¾″ tin metal piece bent at its middle over a 16d nail to form a U as shown in FIG. 11D. To hold the crank pin bearing piece to the spread ends of the rod 11C use two small clamps shown in FIG. 11E. The clamps are strips of tin metal 1/16″ x ½″ formed around the bearing piece.

To assemble the connecting rod as shown in FIG. 11F first lay the two long members along side each other and clamp them together at both ends. The clamps used are a turn and a half of a ⅛-inch tin metal strip. The next step is to place the two spread ends of the rod under the small clamps on the crank pin bearing piece. Then fold back over the small clamps the outer ends of the spread ends. Next you use your pliers to close the clamps and to adjust and fit the inner portion of the bearing piece to a 16d nail. Then apply soldering paste and solder the assembly in an alcohol flame.

The final step is to fit the connecting rod to the crank pin. It may be necessary to file the bearing piece to make it fit between the throw arms. When the bearing piece fits properly over the crank pin use something blunt such as a small file to fold the outer ends of the crank pin bearing piece in and around the crank pin to complete the assembly.

The skirted piston is the next part of the engine to make. The first part of the piston to be formed is the inner drum. It is a piece of tin metal ¾″ x 2½″. First draw a line lengthwise through the middle of the piece as shown by the dotted line in FIG. 12A. Then on this dotted line ½ inch in from one end of the piece use a pointed nail to make a small dent. At 1¼ inch from the first dent and on the dotted line make another dent. At these dents, with an 8d nail filed to a chisel point, cut a ¼-inch X through the metal. Then turn the piece of metal over and hammer back the raised metal to make the piece flat again.

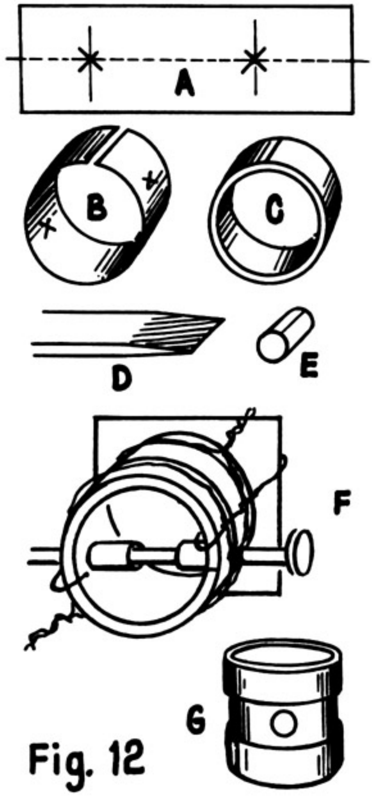


Fig. 12

The next step is to first form and roll the above strip of metal around a ⅝-inch cylinder. Then place the drum formed over a ¾-inch cylinder and with a light hammer tap the metal all around the drum until the ends of the metal piece opens about ⅛ inch as shown in FIG. 12B.

The next step is to form and roll the two end rings shown in FIG. 12C. These rings are strips of tin metal ¼″ x 6″ or long enough to make two turns in the ring. First from about ½ inch in from both ends of both metal strips file the ends to a sharp knife edge as shown in FIG. 12D.

The filing can best be done if the end of the metal strip is placed at the end of a piece of narrow board. After the filing it is best to first form and roll the metal strips on a ⅝-inch cylinder and then roll the two rings on a ¾-inch cylinder.

The two wrist pin bearings are the next to be formed. They are strips of tin metal ¼″ x 1″ formed and rolled on an 8d nail to make short tubes as shown in FIG. 12E.

The next step is to assemble the piston parts as shown in FIG. 12F. First place a ring (12C) over each end of the piston drum (12B). Then around each ring place a band of light-

weight black stove pipe wire and tighten the bands until the butt joint in the inside drum is quite closed.

To add the wrist pin bearings to the piston first use a pointed nail or ice pick to open inward the two Xs in the piston drum. Then use the tapered handle end of a small file to ream and enlarge the two holes until the two bearings (12E) will fit them snugly.

The burr raised in forming the holes in the piston should be pushed back around the bearings to help hold the bearings. To hold the bearings in place while being soldered you insert an 8d nail through the two bearings. First, however, place on the 8d nail a very light film of oil so the nail will not take solder.

The head of the piston is a 1″ x 1″ piece of tin metal. The metal piece is held against the end of the piston assembly while being soldered by means of two black stove pipe wire loops as shown in FIG. 12F. First hook one end of the black wire over the open end of the piston and then bring it back around the 1″ x 1″ head piece and then forward to hook the other end into the piston. With your pliers kink the wire loops slightly on the sides to tighten the head piece against the assembly.

The next step is to apply soldering paste to the joints and then solder the assembly either by immersing it in melted solder or by applying wire solder in an alcohol flame. Before the assembly cools give it a few quick shakes to remove the excess solder. Then remove the wire bands and with your tin snip trim away the extending portion of the head piece. Then use a file to trim, clean and finish the piston.

The wrist pin is a ¾-inch length of an 8d nail. By means of the wrist pin the piston is added to the connecting rod.

FIG. 13 shows the cylinder assembly which includes the cylinder and steam chest. The cylinder is made in two parts. The inner drum or sleeve is a piece of tin metal 1½″ x 2¾″

or the distance around the outer diameter of the piston. The ends of this piece must be cut off square with the sides. First form and roll the metal piece the short way on a ⅝-inch cylinder. Then place the

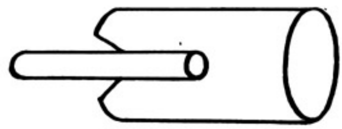


Fig. 13

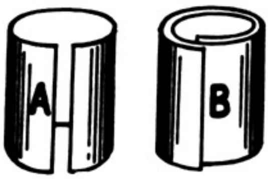


Fig. 14

drum formed on a ¾-inch cylinder and tap it with a light hammer all the way around until the ends open about ⅛ inch as shown in FIG. 14A. This can also be done by rubbing the drum lengthwise all the way around with a piece of wood.

The outer drum shown in FIG. 14B is a strip of tin metal 1½" x 5", first formed and rolled on a ⅝-inch cylinder; then rolled on a ¾-inch cylinder. The next step is to slip the sleeve or drum (14A) inside part 14B. Then place two bands of lightweight black stove pipe wire around the outer drum as shown in FIG. 15A. Tighten the bands until the butt joint of the inner sleeve is closed. Then insert the piston to see how it fits. The piston should fit into the cylinder loosely enough so it will just fall out by its own weight. If the fit is too tight loosen the bands slightly. Opening the joint in the inner sleeve is not serious as it will almost fill again with solder.

If the cylinder is much too large, the inner sleeve should be removed and a small slice each time should be cut from one end of the strip in the inner sleeve. If only a small amount needs to be removed, it should be done with a file.

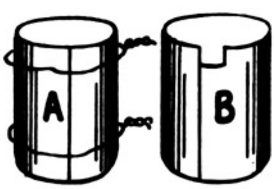


Fig. 15

When the piston fits the cylinder properly apply soldering paste to

the ends of the cylinder, the lap on the outside and to the butt joint on the inside. Then hold the assembly in an alcohol flame and apply the wire solder. When cooled the excess solder should be cleaned away with a coarse file or a jackknife.

The next step is to file out at one end of the cylinder a section ⅛ inch deep and ¼ inch wide as shown in FIG. 15B.

Since it is best to fit the steam chest to the piston of the slide valve you will make the slide valve assembly next. The valve piston is a strip of lightweight tin metal (soup can) 3/16″ x 6½″. First lay the strip against a flat narrow piece of wood and from ½ inch in at one end file the end to a sharp knife edge as was shown in FIG. 12D. Then form and roll the strip around an 8d nail so that the filed end will be on the outside. Around the small drum formed tighten a band of stove pipe wire as shown in FIG. 16A.

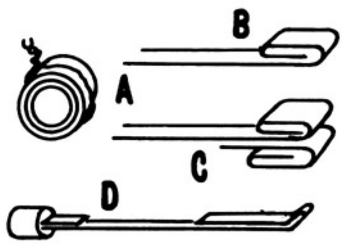


Fig.16

The valve rod is a strip of lightweight tin metal 1/16″ x 5″. At both ends of the strip 3/16 inch in fold the strip two times as shown in FIG. 16B. Then ½ inch in at one end cut the strip to get the short piece that is backed against the other folded end as shown in FIG. 16C. Next insert the double end into the hole in the valve piston. Then apply soldering paste and solder the assembly in an alcohol flame.

The next step is to use a knife blade to scrape the surface of the piston to remove all excess solder. Then file away slightly the sharp edges of the piston so it will not catch in the steam chest. The over all length of the valve and valve rod is 1½ inches. At that length fold the rod and place into the fold a wire paper clip and then with your pliers pinch the legs shut to form an eye. The complete valve and valve rod is shown in FIG. 16D.

The simplest way to form the steam chest is to first file one end of a 1¾-inch lightweight tin metal strip to a sharp knife edge as was shown and described in FIG. 12D. Then 2¼ inches in from the filed edge cut the strip to make a piece 1¾″ x 2¼″ for the steam chest. Form and roll this metal piece the short way around a 5/16-inch metal cylinder and so that the sharp filed edge will be on the inside of the 1¾-inch tube formed.

The next step is to place a black iron wire band around each end of the steam chest as shown in FIG. 17. Then insert into the steam chest the valve piston and tighten the bands until the piston assembly just barely falls out by its own weight. Apply soldering paste to both the inside and outside laps of the tube and then solder the tube in an alcohol flame. A few quick shakes while the tube is hot will remove most of the excess solder. The excess solder on the inside of the tube can best be removed with a large nail cut off square.

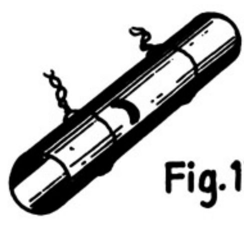


Fig. 17

The last step to complete the steam chest is to file a ⅛″ x ¼″ hole across the tube ¾ inch in from one end as shown in FIG. 17.

The cylinder head is formed from a piece of tin metal 1″ x 1⅜″. On this piece of metal lay out the lines as shown in FIG. 18A. At ⅜ inch in from one end draw a dotted line crosswise. At ⅜ inch in from the first line draw another dotted line crosswise. Then at the same end of the piece ⅜ inch in from each long side draw a solid line as far as the first dotted cross line.

From where the upper solid line meets the first dotted cross line draw a dotted diagonal line up to the right to where the second dotted cross line meets the edge of the metal piece. Then draw the left dotted diagonal line up to

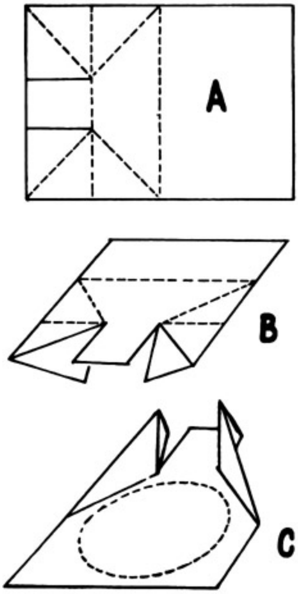


Fig. 18

the corner of the piece. From where the lower solid line meets the first dotted cross line draw the two lower diagonal lines in the same manner.

With your tin snip cut into the metal piece on the two solid lines as far as the first dotted crosswise line. Then with your pliers bend down to a right angle on the two outer diagonal lines as shown in Fig. 18B. Then on the other two dotted diagonal lines bend up to a right angle as shown in Fig. 18C. The cylinder fits into the angle formed as shown by the dotted circle. The ¼-inch projecting tongue is next bent down to a right angle to complete the cylinder head.

The first step in assembling the cylinder assembly is to add the steam chest to the cylinder head as shown in Fig. 19. With the two iron wire bands around the steam chest first loosen the band at the end that is one inch from the hole. Then slip the tongue on the head piece underneath this band and adjust the steam chest so that the hole in it will be between the two bent up sections of the head. Then tighten the black wire band to hold the two members in place.

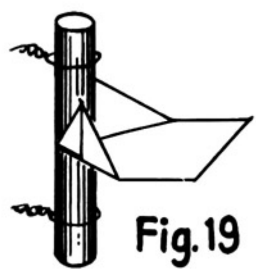


Fig. 19

Next remove the iron wire band at the end of the cylinder with the cut out section. Then place this end of the cylinder

against the cylinder head so that its cutout section at the end will be between the two bent up sections of the head. Then tighten an iron wire band around the cylinder and steam chest as shown in FIG. 20.

You next make a hook at one end of a 4½-inch length of black iron wire. Then place the hook over the edge at the open end of the cylinder and bring the wire down around the head and back up over the edge at the open end on the opposite side. With your pliers kink the wire band on both sides of the cylinder to bring the head up against the cylinder.

The next step is to close or fill the opening between the cylinder and steam chest with small wads of clean steel wool. To prevent the wads of steel wool from going in too far bend a 1/32″ x 1″ tin metal strip at its middle to form a U. Place this U into the opening and at about ⅛ inch in from the ends of the U legs bend the legs to make hooks that will hold the U in place. After the wads of steel wool have been packed in, place the middle of a 2½-inch length of black iron wire over the opening and bring the two ends back to the tongue of the head piece where the ends are twisted together and tightened as shown in FIG. 20.

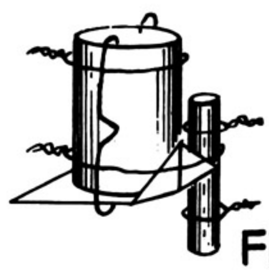


Fig. 20

After checking to see that the steam chest is properly aligned to the cylinder and that the head piece does not gap away from the cylinder, apply the soldering paste and then solder all the joining edges of the assembly in an alcohol flame. While the assembly is cooling hold it vertically to allow more solder around the head piece and the cylinder.

After the assembly has cooled and the wire bands removed the outer projecting part of the head piece is cut

away with a tin snip and then filed smooth and even with the cylinder.

The next step is to test the cylinder assembly to see if it leaks air. Any place in the assembly that failed to solder properly should be gone over and corrected with a small soldering iron.

The final step is to add the cylinder assembly to the engine base. First you need to add to the front end of the rear projecting sections a 3/16″ x 1½″ tin metal strip as shown in FIG. 21. At each end of this metal strip ¼ inch in from the end make a fold. Then slip the two folds over the two projecting sections so that the metal strip hangs like a hammock between the sections. This metal strip will prevent the cylinder from being pulled down too far between the projecting sections.

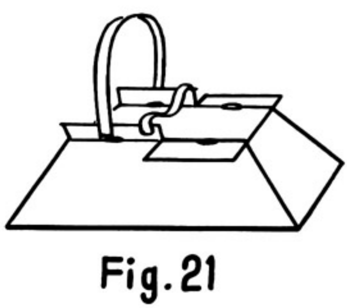


Fig. 21

The metal band that holds the cylinder assembly in place on the engine base is a tin metal strip ⅛″ x 4″. The ends of this metal strip are pushed through the two rear oblong holes as shown in FIG. 21. Then after the cylinder has been inserted into the loop formed the two ends of the metal strip are twisted together below the cylinder inside the base and then tightened with a pair of pliers.

The two flywheels for the engine are the parts to be made next. The disk type of flywheel shown in FIG. 22 is the simplest type to make. Since both flywheels are made the same the directions given here will be for only one.

First cut from tin can metal a 2″ x 2″ square. Then on

this square of tin metal draw the two diagonals to locate the center as shown in FIG. 23. Now use a small nail to make a slight dent at the center of the square. Then set a compass to a 1-inch radius and mark on the metal square a 2-inch circle as shown by the dotted circle in FIG. 23.

Fig. 22

Fig. 23

In cutting out the disk from the tin metal square with your tin snip it is best to first cut away the four corners of the square up to the marked circle. Then cut away the eight newly formed corners up to the marked circle. Now use a file to remove the small newly formed corners up to the marked circle and to make the disk round.

You next place the cut out metal disk on the end grain of a piece of wood and with a hammer and a 40d nail cut off square punch out a hole at the center of the disk. You strike the first blow to the 40d nail gently so you can check to see if the hole is at the center of the disk. Then strike the second blow hard enough to punch out the hole.

Since this 2-inch metal disk bends quite easily, a 1¼-inch metal disk is added to the 2-inch metal disk in the assembly. This smaller 1¼-inch tin metal disk is marked, cut and punched the same as the larger 2-inch disk.

The rim rings for the flywheel are tin metal strips which are best cut from a 5-inch diameter shortening can or a one-pound coffee can. The paint on the coffee can strips can be easily scraped off with a knife blade. For the outer rim ring of the flywheel you cut a tin metal strip ⅜″ x 15″ and for the two inner rim rings cut two tin metal strips 3/16″ x 15″

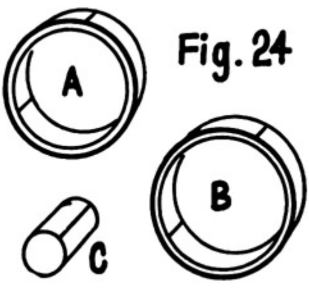


Fig. 24

The 3/8″ x 15″ tin metal strip is formed and rolled on a 1¼-inch cylinder, such as a flashlight cell, to form the outer rim section as shown in FIG. 24A. The two 3/16″ x 15″ tin metal strips are formed and rolled on a 1½-inch cylinder to make the two inner rim sections as shown in FIG. 24B.

The hub for the flywheel is a tin metal strip 3/8″ x 2″. Form and roll this metal strip on a 40d nail or a ¼-inch cylinder to make a drum as shown in FIG. 24C.

In assembling the flywheel, first use a tapered punch or other tapered object to ream and enlarge the hole in both the large and the small tin metal disk until the hub (24C) will fit the hole snugly. Then insert the metal hub into the holes of both disks and adjust the two disks to the middle of the hub.

Now by pushing against the inner end of the metal strip in the outer rim section 24A, the section can be expanded until it can be slipped over the larger tin metal disk as shown in FIG. 25 and so that the metal disk will be in the middle of the outer rim ring section.

Since the two inner rim rings were formed on a 1½-inch cylinder their diameter size must be reduced in order to fit inside the outer rim ring. This reduction in diameter is done by a pulling action on the inner end of the metal strip in the ring. An inner rim ring is placed on each side of the two-inch metal disk.

Fig. 25

You next place and tighten a black iron wire band around the

outer rim of the assembly as shown in Fig. 25. To make certain that all the rim rings will stay in place while being soldered you place three black iron wire clamps across the rim rings as shown in Fig. 25. The inner rim rings can now be expanded and tightened by pushing against the inner ends of their metal strips.

The final step is to adjust the hub to its proper perpendicular position to the two metal disks and so that the disks are at the hub's middle. Then apply the soldering paste and solder the assembly either by immersing it in melted solder or by applying the wire solder in an alcohol flame. If the soldering is done in an alcohol flame the hub and small disk should be soldered first. You next remove the wire band and clamps and then check and adjust the flywheel to make it run true.

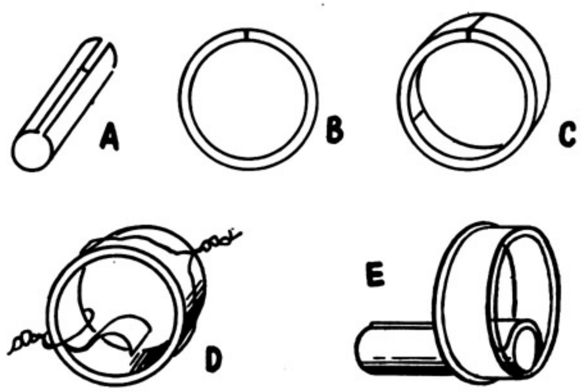


Fig. 26

The grooved cam for the engine timer shown in Fig. 26E is a detachable part of a flywheel. The first part of the grooved cam to make is a tin metal sleeve shown in Fig. 26A and by which the grooved cam is attached to the flywheel. This sleeve is a piece of tin metal 9/16″ x ¾″ formed its long way around a 30d nail.

The grooved cam consists of an inner and outer rim ring that are separated by a wire ring to form the groove. The first part of the grooved cam to make is the wire ring shown in FIG. 26B. This wire ring can best be made by forming a 2¼-inch length of clean bright No. 14 copper wire around a ⅝-inch cylinder.

The two tin metal strips that form the inner and outer rings in the grooved cam ring are 3/16″ x 5″. At one end of each metal strip from about ½ inch in file the end to a sharp knife edge as shown and described in FIG. 12D.

You next form and roll one of the 3/16″ x 5″ metal strips on a ⅝-inch cylinder to make the inner cam ring as shown in FIG. 26C and in which the filed end of the strip is on the outside of the ring. Then form and roll the second 3/16″ x 5″ metal strip on a ⅝-inch cylinder to make the outer cam ring in which the filed end of the strip is on the inside of the ring.

The first step in assembling the grooved cam ring is to expand the outer cam ring and slip it over the copper wire ring (26B). Then tighten a black iron wire band around the cam rim ring. You next reduce the diameter size of the inner cam ring so it can be slipped snugly inside the copper ring.

Now place the grooved cam ring against a flat surface and with a small nail or other pointed object push the copper wire ring down so it will be even with the edges of the two metal rings.

At about ⅜ inch in from the inner end of the metal strip in the inner cam ring place an iron wire band around the cam ring assembly as shown in FIG. 26D. This wire band will hold the inner metal strip in place when you lift and form its inner end over a 16d nail to make a sort of clamp that will hold the sleeve (26A) as shown in FIG. 26E.

Before adding the sleeve to the grooved cam ring the sleeve should be placed over the crankshaft and pinched shut until it slips off the crankshaft easily. Then one end

of the sleeve is slipped under the formed clamp in the grooved cam ring as shown in FIG. 26E.

When the metal sleeve has been adjusted to its perpendicular position to the grooved cam ring and its open section is towards the center of the cam ring, you apply the soldering paste and solder the assembly in an alcohol flame.

While the assembly is still hot be sure to give the assembly several quick shakes to remove excess solder that may be held in the cam groove between the two metal cam rings. You next remove the wire bands and make the assembly ready to be added to the flywheel.

Fig. 27

To add the grooved cam assembly to the flywheel requires a small metal drum or tube to fill the space between the flywheel hub and the cam sleeve. This metal drum or tube shown in FIG. 27A is a piece of lightweight tin metal ⅜″ x 1½″ formed and rolled the short way on a 30d nail or a 3/16-inch cylinder.

First make the drum fit the cam sleeve. If necessary use the tapered end of a nail set to expand the drum until it slips over the cam sleeve easily. Then slip the hub of the flywheel over the drum.

To hold the cam sleeve firmly to the drum insert into the open section of the cam sleeve a tapered tin metal key shown in FIG. 27B. This key is a tin metal strip about two inches long and which tapers from 3/16 inch or more at one end to a point at the other end.

When the tin metal key is pulled through between the cam sleeve and the metal drum it adds metal between them and which will hold them firmly together. When the key is in place the two extending ends of the key are twisted off and their stumps made smooth.

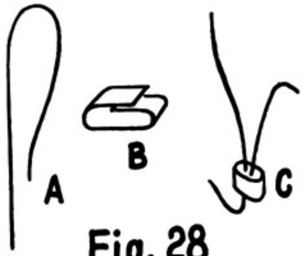


Fig. 28

The last part of the engine to be made is the valve rod guide and adjustment arms shown in Fig. 28C. This device not only serves as a guide for the valve rod but also as an adjustment for timing the engine.

This last part can be made from either a straightened wire paper clip or from a piece of heavy stove pipe wire. In either case cut a piece of wire 3½ inches long.

Then from about ¼ inch in from one end file and clean the wire so it will take solder. Also at ¾ inch in at the other end of the wire file and clean a section about ⅜ inch long. Then bend the wire to make a loop as shown in Fig. 28A and so that the cleaned end will meet the other end at ½ inch in from that end of the wire.

You next form the end of a ⅛-inch tin metal strip a turn and a half around the two legs of the loop and cut away the surplus strip. This small clamp shown in Fig. 28B is placed over the two legs of the loop at the end of the shorter leg. Now apply soldering paste to the clamp and wire legs and solder them in an alcohol flame.

The next step is to bend the single ½-inch leg sharply to a right angle to form the shaft on which the guide arms pivot. Then cut the short legs of the loop so it will be 1¼ inch long from the pivot. The longer leg of the loop is now straightened and cut so it will be 1½ inches long from the pivot.

At ⅛ inch in from the end of the longer leg bend the wire sharply to a right angle in the same direction as the pivot and as shown in Fig. 28C. Then at ⅛ inch in from the end of the shorter leg bend the wire sharply to right angle in the opposite direction to the pivot.

You now insert the pivot or shaft of the valve rod guide into the small bearing in the front side of the engine base. Before you insert the slide valve into the steam chest bend the valve rod to almost a right angle at ¼ inch in from the eye or bearing. The amount of bend in the valve rod will give additional adjustment in timing the engine. After inserting the slide valve into the steam chest connect the small bearing in the valve rod to the short bent portion of the longer arm of the valve rod guide.

After the grooved cam has been added to the crankshaft you insert the short bent portion of the shorter guide arm into the groove of the cam. If all the parts of your engine operate freely and smoothly the engine is ready to be timed.

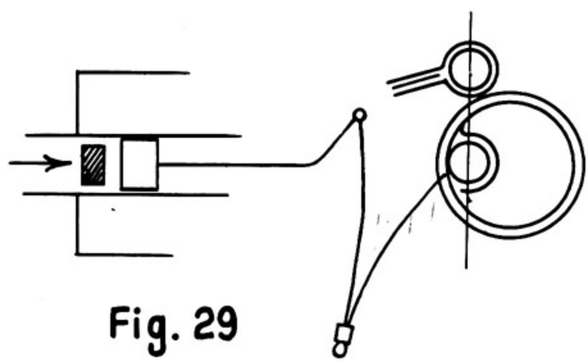


Fig. 29

By timing one means the relative positions of the slide valve and the piston or crank at a given time in a revolution of the flywheel. FIG. 29 is a simple skeleton drawing to show the proper relative positions of the crank, cam and the slide valve.

You will notice that when the port hole is open so the steam or air pressure can enter the cylinder, the grooved cam leads the crank by 90 degrees. The accurate timing can only be determined by putting pressure into the steam chest.

In this engine the timing can be changed in any of three ways: first, by advancing or retarding the grooved cam on the crankshaft; second, by increasing or decreasing the amount of spread in the valve guide arms; third, by increasing or decreasing the amount of bend in the bent portion of the valve rod.

The amount and kind of adjustment in timing to be made can only be determined after blowing into the steam chest to see what the engine will do. When the engine spins most easily and rapidly the timing will be nearest correct.